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ABSTRACTS OF TECHNICAL PAPERS AND POSTER PRESENTATIONS

WATER REUSE SYMPOSIUM

March 25-30, 1979
Washington, D.C.
Twin Bridges
Marriott Hotel

THEME:
"Water Reuse—
From Research to
Application"

CO-SPONSORED BY:

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This document consists of 150 abstracts of technical papers and poster presentations dealing with the topic of water reuse. Abstracts are organized firstly according to the sessions from one to fourteen and afterwards by poster presentation according to the date presented. Title, author, and author affiliation are noted. No indexes are included. General research as well as research applications are covered. Titles include: Applied Science and Its Role in Addressing Problems Relating to Renovation and Reuse of Water; Department of Defense Involvement in Water Reuse; The President's National Water Policy in Relation to Water Reuse; Reclamation of Secondary Effluent for High-Quality Industrial Reuse in Saudi Arabia; and Hygienic Aspects of the Dispersion of the Enteric Bacteria and Viruses by Sprinkled Irrigation of Wastewater.

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ABSTRACTS OF PAPERS AND POSTER PRESENTATIONS

WATER REUSE SYMPOSIUM
MARCH 25-30, 1979
WASHINGTON, D.C.

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The following abstracts were not submitted in time for publication but will be available as a separate handout.

AUTHORS	PAPER/POSTER TITLE	SESSION
Thomas C. Jorling U.S.E.P.A.	Highlights of EPA Reuse Program	Monday, No. 1
T. H. Lau	Reuse Planning in Hong Kong	Tuesday, No. 6
Peter E. Odendaal	South Africa Reuse Overview	Wednesday, No. 8
John S. Harnett	Reuse Planning at EBMUD	Thursday, No. 11
William L. Chase	A Formula for Success	Thursday Poster

Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Theme Address - Water Reuse - From Research to Application

AUTHORS: Lt. Colonel LeRoy H. Reuter

AFFILIATION: U.S.A.M.B.R.D.L.

DATE OF SESSION: Monday, March 26 *SESSION NO:* 1

The time is right for this conference. A conference dedicated to presenting the full spectrum of water reuse - from research to application. Water reuse is the main event; fourteen sessions with 155 papers, both poster and formal, and plant tours. Gathered are the champions of reuse and for balance some challengers. Uses in industry, agriculture, and municipalities are presented. Research, policy, plans, and status reports on operating systems are all covered on a US and on an international level. Each federal department/agency with vested interest is a sponsor and is actively participating.

What stands in the way of broader and more rapid implementation of water reuse? Let's start with the opinion of the "man on the street." He almost invariably focuses first on the very limited, most complex water reuse application - that of producing drinking water from domestic waste. My guess this is because drinking is the individual's most intimate use of water.

Another factor is that there is not a pressing nationwide need for reuse in the United States; therefore, it is difficult to get major federal support for programs with immediate application to selected regions and localities.

Americans are not traditionally good conservationalists. Reused water may have an image of being second rate. What kind of people buy used water?

Water supply and waste treatment have not been historically considered as growth limiting factors by politicians. We have diligently pointed ourselves into a corner by making tremendously large investments in collection and distribution systems.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Applied Science and Its Role in Addressing Problems Relating to Renovation and Reuse of Water

AUTHORS: Jack T. Sanderson

AFFILIATION: National Science Foundation

DATE OF SESSION: Monday, March 26 *SESSION NO:* 1

Science has played an important role in development of the present understanding of the nature of water and this knowledge has been used to solve problems relating to its availability, use and reuse. This role cannot become less significant and important as the challenges of future needs for water are faced.

The National Science Foundation's programs in support of basic sciences and engineering constitute over 90 percent of its budget. Accounting, as it does, for approximately 25 percent of all public expenditures for basic research in the United States, there can be little doubt of the Foundation's significant role in the search for still better understanding of basic scientific and engineering principles that will lead to many applications of significance and importance in the management of water. For example, a better understanding of fundamental laws which govern the atmosphere may permit the management of weather which in turn could lead to more fundamental and satisfactory approaches to dealing with the extremes of water supply, viz. floods and drought.

The management of water quality will likewise benefit from advances in basic science and its application to permit renovation and reuse of wastewater. The National Science Foundation's role in this respect is likely to be one of concentrating its support on the basic sciences but selectively focusing its support on those problems in which the leverage of science and technology is substantial and the focused efforts are both timely and scientifically ready. Focusing as it does on the state-of-the-art of renovation and reuse of wastewater, this conference will play an important role in identifying important gaps in knowledge many of which are likely to be best approached by more fundamental understanding of natural laws and their application toward the solution of important national problems.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Department of Defense Involvement in Water Reuse

AUTHORS: George Marienthal

AFFILIATION: Department of Defense

DATE OF SESSION: Monday, March 26 *SESSION NO:* 1

Water reuse presents certain advantages to the Department of Defense (DOD) as it does to other water users. Some of these advantages are savings in water and wastewater treatment costs, manpower savings, fuel and energy conservation, and minimization of adverse environmental impact as a result of defense related operations. In addition, DOD is responding to the Federal Water Pollution Control Act (P.L. 95-217) which states that reuse must be considered as an alternative in new construction of treatment plants.

Potential reuse applications within DOD include permanent and semi-permanent installations throughout the world, advanced base planning, field operations (training and combat) and ships.

Within DOD, there are two jointly sponsored research programs. The objective of the first, a Navy-Army project, is to develop water quality criteria for recycled water. Non-potable criteria for water intensive operations are first priority. The development of potable criteria may be undertaken during the program, if the considerable research is justifiable against military requirements. The objective of the second program is the development of on-line analyzers to determine organics in water and wastewater. This project is jointly sponsored with EPA. In addition to these jointly sponsored programs, the Air Force is implementing a reuse system at McClellan Air Force Base by using a cascade water reuse model. The Army is implementing reuse in vehicle washracks. The Navy has completed studies on the recycle of laundry and photographic wastes aboard ships.

DOD is committed to conducting wastewater research for its special and unique applications and to participating jointly with other agencies, organizations, states, and municipalities in implementing water reuse. In addition, the use of Department of Defense installations as demonstration facilities for recycle-reuse projects is actively being pursued.

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WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: The President's National Water Policy in Relation to Water Reuse

AUTHORS: Guy R. Martin

AFFILIATION: U. S. Department of the Interior

DATE OF SESSION: Monday, March 26 *SESSION NO:* 1

The President began reviewing water policy and the status of Federal action on water problems in 1977. On June 6, 1978, he sent to the Congress 13 water policy initiatives which were aimed at improving planning and management of Federal programs, providing a national emphasis on water conservation, increasing Federal-State cooperation in water resources planning, and increasing attention to environmental quality. Nineteen Federal interagency task forces were formed to carry out the 13 initiatives, with Secretary Andrus as Chairman. The Secretary designated Assistant Secretary Martin to oversee the operation of these groups. Their work is partially completed, and their Second Progress Report has been submitted.

The participation of all interested groups is necessary to turn the recommendations of these task forces into real programs for the Nation. Understanding of the rationale for a national water policy is basic to the success of the program. How much money does useable water really cost? What institutional changes are needed to make best use of available water in water-short areas? What is the role of industry in cooperating to conserve and protect water? What can new technologies provide to help? How can the Federal Government effectively work with local and State governments, with industry, with agriculture, and with the general public to develop a national water policy which is acceptable to all these groups?

The most promising new source of water is water reuse, a comparatively new technology. A rapidly expanding industry is being developed to produce water reuse technology. What part should Government play in the growth of that industry? What involvement should the reuse technology industry have in the development of national water policy? The cornerstone of the President's message is conservation. Water reuse is a prime example of the President's conservation initiatives in action.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Reclamation of Secondary Effluent for High-Quality Industrial Reuse in Saudi Arabia

AUTHORS: Anton A. Kalinske, John F. Willis, & Stephen R. Martin

AFFILIATION: Camp, Dresser & McKee, Inc.

DATE OF SESSION: Monday, March 26 *SESSION NO:* 2

Three driving forces have shaped design of a 5-mgd water-reuse system that will convert secondary domestic effluent to high-quality industrial process water at Riyadh, Saudi Arabia. First, three grades of water supply are required in the client's current refinery-expansion projects; these grades include supplies for fire protection, cooling-water makeup, and steam boiler feed water. The last grade of water must be treated to very high quality, with hardness, 0; TDS below 10 mg/l; ammonia and COD, 0; silica below 0.5 mg/l; and TSS below 0.5 JTU. Second, available resources in the area are very limited. The design must maximize conservation and recycling of materials. Third, the technology required to produce this high-quality water from effluent containing more than 3000 mg/l TDS, must be matched by minimum operations-and-maintenance (O&M) costs and, accordingly, by a high degree of operational simplicity and reliability.

Camp Dresser & McKee (CDM) and Foster Wheeler Italiana (FWI) have selected and designed a stepped process train that stores reclaimed effluent at key points, both for appropriate use at that level of treatment and for feed to the next higher series of treatment processes. To achieve the highest level of treatment, the secondary effluent will be passed successively through coarse screens, aerated surge ponds, aerated grit chambers, two solids-contact clarifiers in series with intermediate recarbonation, chlorination and pH adjustment, cooling towers, polymer mixing, dual-media gravity filters, granular activated carbon (GAC) columns, two reverse-osmosis (RO) units in series, and mixed-bed ion exchange (IE). Stable, disinfected water for fire protection will be stored after the second stage of lime treatment and chlorination, at a design flow of 100 gpm (22.7 cmd). Reclaimed water for cooling tower makup will be stored after the first stage of RO treatment at a design flow of 1410 gpm (320.5 cmd).

Throughout, chemical consumption is minimal. The poor availability locally of activated carbon, lime, magnesium (for silica removal and as a coagulant aid) prompted design of resource-recycling features that include regeneration of spent carbon, recalcination of the lime sludge, and recovery of magnesium from the lime sludge (accomplished in a magnesium-hydroxide dissolving tank with the use of carbon dioxide from the recalcination furnace stack). Carbon dioxide from the recalcination process is recycled also to the recarbonation step of the reclamation process. The process scheme will provide treatment flexibility, resource conservation, and minimum O&M and capital costs while meeting stringent water-quality criteria under demanding exogenous conditions.

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WATER REUSE SYMPOSIUM
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TITLE OF PAPER: Hygienic Aspects of the Dispersion of the Enteric Bacteria and Viruses by Sprinkled Irrigation of Wastewater

AUTHORS: Hillel I. Shuval, B. Teltsch

AFFILIATION: Hebrew University of Jerusalem

DATE OF SESSION: Monday, March 26 *SESSION NO:* 2

Israel, a country suffering from severe shortages of water resources, by the year 1978 already was utilizing over 95% of its ultimate total water reserves. Wastewater utilization primarily for agricultural irrigation has become an integral part of the national water resources planning policy. This has resulted in the development of some 50 municipal and 200 rural wastewater utilization projects, most of which practice land application of wastewater by sprinkler irrigation of crops.

Studies on the hygienic aspects of sprinkler irrigation have demonstrated that enteric bacteria and viruses can be detected at considerable distances downwind of sprinkler irrigation fields. Coliforms have been detected 450 meters downwind, enteropathogenic Salmonella sp at 60 m., whilc Echovirus and Coxsackievirus were detected at 100 m. Studies of meteorological factors affecting the survival of aerosolized coliforms indicate that as relative humidity increases, so does survival, independent of other factors. Ten times more aerosolized bacteria were detected at a given sampling point during nighttime irrigation than by day. When initial concentration of coliforms in sprinkler irrigated wastewater dropped below 10^3/loo ml there was no detection at downwind sampling stations with either Anderson samplers or a high volume viable aerosol sampler.

To evaluate the possible epidemiological significance of wastewater irrigation, a retrospective study was carried out in agricultural settlements (kibbutzim) practicing various forms of irrigation.

The incidence of enteric communicable diseases in 77 kibbutzim practicing wastewater spray irrigation with partially treated non-disinfected oxidation pond effluent was compared with that in 130 kibbutzim practicing no form of wastewater use. The incidence of shigellosis, salmonellosis, typhoid fever, and infectious hepatitis was two to four times higher in communities practicing wastewater irrigation. No significant differences were found for the incidence of streptococcal infections, tuberculosis, and laboratory-confirmed cases of influenza. Nor were differences found for enteric disease rates during the winter irrigation season.

This study does not provide definitive proof that the primary mode of the pathogen transmission was airborne aerosolized pathogens resulting from sprinkler irrigation with wastewater. Other routes of infection, such as direct contact between irrigation workers and other residents in the communities is equally possible. However, these studies do indicate that a potential public health risk does exist when only partially purified non-disinfected wastewater is used for land application in the close proximity of residential areas. It is concluded that wastewater treatment processes leading to a significant reduction of enteric bacteria and viruses prior to sprinkler irrigation with wastewater in the vicinity of residential areas is a minimum precaution required to provide reasonable protection of the public health.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Water Reuse - The Air Force Experience From Research to Application

AUTHORS: Gary R. McNutt

AFFILIATION: U. S. Air Force

DATE OF SESSION: Monday, March 26 *SESSION NO:* 2

This paper discusses the Air Force involvement in Water Reuse from our initial and follow-on research efforts to a practical application and future emphasis areas. Preliminary investigations began in 1973 into closed loop systems, recycling secondary treated municipal wastewater as a source of makeup water for potable quality use. This investigation was a reaction to the anticipated high cost of advanced treatment necessary to comply with the then newly enacted Federal Water Pollution Control Act Amendments of 1972 and the availability of the resultant quality water resource. There was a reluctance on the part of Air Force researchers to waste, by discharge, water in areas where shortages of usable water were developing. Advanced treatment processes were reviewed and characterized as were the health criteria available at that time. Models of cost and performance for individual processes were incorporated into a program for the conceptual design of reuse systems. The conclusion drawn from this effort was that closed loop recycle was not feasible due to the lack of adequate health effects criteria and the unreliability of advanced treatment processes at that time (1974).

The initial effort did strongly suggest the potential for subpotable reuse and the value of a computer model to evaluate the potential of cascading reuse alternatives. This effort carried forward the earlier modeling and characterized water quality and quantity demands of various base activities as well as the extent of quality degradation through use. Typical base activities included waste treatment plants, jet engine test cells, cooling towers, vehicle wash racks, depainting facilities and landscape irrigation. Four bases were surveyed including Andrews AFB MD, Davis-Monthan AFB AZ, March AFB CA, and Peterson AFB CO.

The model application was conducted in two phases for each base. Phase I was a survey of base activities to include all sources and sinks of water to include quantities generated and discharged and quality requirements and degradation. Phase II was the application of the model. Various networks as suggested by the model were selected and optimized by inputing existing treatment capabilities and "real world" limitations. Costs for the more promising networks were estimated by the model using data for capital costs, operating and maintenance costs, and piping and pumping costs updated to current values as a means of alternative comparison.

The Air Force is currently participating with the Army and the Navy in the development of water reuse criteria for military applications as well as renewing our efforts to conserve the use of fresh water at our facilities.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Treatment Technology for Wastewater Reuse

AUTHORS: Robert B. Williams, Justine A. Faisst, and Gordon L. Culp

AFFILIATION: Culp/Wesner/Culp Engineers

DATE OF SESSION: Monday, March 26 *SESSION NO:* 2

This paper describes a study recently concluded for the Department of the Interior, Office of Water Research and Technology evaluating the feasibility of wastewater reuse. The paper outlines the various levels of wastewater treatment achievable with existing technology. These levels are matched with potential beneficial uses which could be satisfied by direct reuse. Economic feasibility is determined by comparing incremental costs for additional treatment beyond secondary with the costs of using existing fresh water supplies or developing new ones.

Reuse was found economically feasible for beneficial uses requiring only secondary effluent such as agricultural irrigation, once-through cooling and primary metals industries. Slightly higher quality, filtered secondary effluent, is suitable and feasible for landscape and urban irrigation and in the petroleum industry for secondary oil recovery. Higher treatment levels (nutrient removal) are economical for recycle cooling and boiler make-up water. Other potentially economical industrial uses are chemical and paper manufacturing. Domestic reuse was found economically feasible based on existing and projected water costs even though a very high level of treatment is required.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25–30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Development of a Testing and Evaluation Program for Operating - "The Experimental Estuary Water Treatment Plant"
AUTHORS: Charles C. Johnson, Jr. and Donald R. Aukamp

AFFILIATION: Malcolm Pirnie, Inc.

DATE OF SESSION: Monday, March 26 *SESSION NO:* 2

A one million gallon per day pilot treatment plant has been designed and is being constructed to evaluate the feasibility of augmenting the metropolitan area water supply from the Potomac River Estuary. The source has an abundance of fresh water during periods of normal flow in the river. During periods of low flow the quality of the estuary water deteriorates significantly as it is influenced by tidal action and discharges from the Blue Plains Regional Sewage Treatment Plant. It is during these periods of low flow that the need to augment the water supply sources in the area is most critical.

The primary purpose of this demonstration project is to determine if a water quality acceptable for drinking can be produced under the worst conditions that might prevail in the estuary. The conditions likely to prevail were established by a water quality modeling program patterned after the EPA Dynamic Estuary Model. Treating secondary effluent from the adjacent Blue Plains Plant will simulate the worst condition. The parameters to be measured for evaluating treated water quality were developed in cooperation with two committees of the National Academies of Science that are advisory to the Corps of Engineers on the scientific aspects of this demonstration project. The statistical validity of the sampling process and analytical precision will be guided by a "time series model" expressly developed for this project. Existing and proposed drinking water standards will be used when applicable for evaluation of treated water quality. Since there are no specific standards for many of the parameters used in the evaluation, a second method of consideration will be used to supplement the existing standards. The testing and evaluation program developed for this project has been designed to provide an exceptional data base for making the final judgment on treated water quality.

Finally, the demonstration will provide information on the staffing required to operate a plant for this purpose. Also a record will be kept on the cost of operating and maintaining a water treatment plant for this purpose. This information will be useful in developing assumptions on the design and operation of a full scale plant that might be constructed under the same or similar conditions.

ABSTRACT

WATER REUSE SYMPOSIUM
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TITLE OF PAPER: Demonstration of Potable Water Reuse Technology - the Denver Project

AUTHORS: 1) M. R. Rothberg, 2) S. W. Work, 3) K. D. Linstedt and, 4) E. R. Bennett

AFFILIATION: 1 & 2) Denver Water Department, 3 & 4) University of Colorado

DATE OF SESSION: Monday, March 26 *SESSION NO:* 3

The Denver Water Department is the only water utility in the United States acknowledging both its desires and ultimate needs for a potable water reuse scheme. The Department has been actively involved in examination of reuse technology since the late 1960's. These studies have been a direct result of the realization that continued growth and development in the water short Denver area would require new sources of water which may not be completely obtainable from conventional raw water facilities, and the legal necessity that the Denver Water Department examine the possibilities of successively using its transmountain water.

The Department's evaluation of Successive Use began with numerous studies of water use patterns, marketing analyses, and public relations surveys. The preliminary pilot work for the Department's Successive Use Program involved evaluation of advanced waste treatment technologies for upgrading secondary effluent or other low quality waters. Through these multidisciplinary evaluations, Denver has determined that only direct potable reuse can provide the necessary quantities of water for meeting future demands.

During the last five years, research at the Department's Pilot Plant has been aimed at finding various unit processes for complete and potable renovation of water. The results of this pilot work, along with combining the expertise of many people throughout the world led to a conceptual design of a potable reuse demonstration plant. With recent successes in locating funding assistance for the construction and operation of this plant, the Department is now ready to begin the engineering design and construct a facility which will demonstrate the abilities to reliably and consistently produce a potable quality water.

Based on advances in technology and data obtained through continued operation of the Department's pilot facilities, the conceptual design has been modified slightly. The facility is to be sized at 1 mgd capacity and will consist of: single stage lime clarification, recarbonation (with piping to permit two-stage operation), ballast, ponding, filtration, selective ion exchange using clinoptilolite for ammonia removal, ozonation, carbon filtration, (designed to operate in single or two-stage modes). Following carbon filtration 0.1 mgd would be subjected to reverse osmosis and chlorine dioxide disinfection. The remaining 0.9 mgd carbon filter effluent would be disinfected and available for nonpotable use. Other technical areas to be explored include R.O. brine disposal techniques and an alternative carbon regeneration technology other than multiple hearth.

The modified treatment scheme will be designed and constructed during the next three years. The facility will then be operated for five years under an intensive regime of both analytical quality and health effects testing. These programs will encompass the detailed characterization of the influent and effluent from the plant along with data of animal response to a diet including concentrated product water.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Recharging Aquifers at Water Factory 21

AUTHORS: Neil M. Cline

AFFILIATION: Orange County Water District

DATE OF SESSION: Monday, March 26 *SESSION NO:* 3

Orange County, California, continues to be one of the fastest growing communities in the United States. To support the continuing expansion in this semi-arid region, it has been necessary to develop innovative water resource systems. The area's water supply is provided by groundwater, imported water from the Colorado River and Northern California, and limited use of reclaimed wastewater. Groundwater satisfies approximately 60 percent of the demand within the District, and in times of drought as much as 80 percent. To protect the groundwater from seawater intrusion, the Orange County Water District has developed a hydraulic barrier that includes 23 injection wells utilizing reclaimed water for injection. The barrier water flows seaward to forestall ocean water incursion, and landward where it is intercepted by coastal community wells for use as a portion of the local water supply.

As a result of statewide water problems, philosophies, and the rapidly rising costs of energy to pump water from distant watersheds, and coupled with the availability of drought-free supply, the Water District has determined that wastewater salvage and reuse is the optimum solution to control seawater contamination of its invaluable groundwater reserve.

The Orange County Water District in cooperation with the United States Environmental Protection Agency and the Office of Water Research and Technology, USDI, has constructed Water Factory 21, a 15 million gallons per day advanced waste treatment plant that includes lime clarification, recalcination, ammonia stripping, recarbonation, chlorination, filtration, activated carbon adsorption, and reverse osmosis demineralization of secondary effluent to produce a high quality water that satisfies national, state and local water quality standards for groundwater replenishment.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Wastewater in Drinking Water Supplies

AUTHORS: 1) Michael D. Swayne, 2) Greg Boone, 3) John S. Lee, 4) James Morgan, and 5) John English
AFFILIATION: 1,2,3,4) SCS Engineers, 5) U.S.E.P.A. - MERL

DATE OF SESSION: Monday, March 26 *SESSION NO:* 3

Water reuse is a term generally used in relation to the treatment of wastewater generated by one activity to be used as the water supply for another activity. In these cases, the reuse application is designed as an integrated system, ensuring that the treated wastewater meets supply specifications in terms of both design and operation. Use of municipal and industrial wastewater after discharge and dilution by receiving waters is another form of water reuse that is widely practiced. However, this form of reuse poses a number of technical, political and social problems. It is often difficult or impossible to do an adequate system design because the wastewater sources (dischargers) are numerous and outside the control of the water supply agency. Since the wastewater is conveyed by streams and rivers with uncontrolled characteristics, the wastewater will be modified in a manner which is difficult to estimate from the existing state of knowledge. This is particularly true for many substances now suspected of being a health risk. These include certain heavy metals, pesticide/insecticides, aromatics, aliphatic solvents, phenols and several others, where data on their fate in the environment is limited. Even more basic is the fact that it has been difficult to simply determine the identities and characteristics of wastewater dischargers upstream from water supply points.

The purpose of this paper is to describe a study performed by SCS Engineers for EPA MERL (1) to facilitate the identification and the extent to which dischargers impact water supply systems in the United States. This project included data collection, data base development, data verification and entry, and analysis components.

The study identified 1246 utilities using surface water from 194 basins serving 525 cities with populations greater than 25,000. The results were tabulated to show for each utility: the number of upstream wastewater dischargers by type, estimation of cumulated wastewater discharge flow and the ratio of wastewater flow to stream or river flow. The results ranged from 142 utilities with no dischargers identified to many utilities where the wastewater constitutes a major portion of the water supply. Several utilities were determined to be using water from a source whose flow was less than the combined upstream discharge flows. In extreme cases, water in some basins was determined to have been completely reused several times before ultimate discharge into the ocean.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25–30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Water Reclamation Facility at Palo Alto

AUTHORS: Lloyd C. Fowler

AFFILIATION: Santa Clara Valley Water District

DATE OF SESSION: Monday, March 26 *SESSION NO:* 3

The Santa Clara Valley Water District, water resources management agency for Santa Clara County, California, noted apparent saline water intrusion in shallow aquifers near San Francisco Bay. This saline intrusion could potentially contaminate the deeper heavily pumped water quality aquifers. A barrier was needed to protect the groundwater basin.

The most feasible protection was a hydraulic barrier formed by the injection of freshwater. Water supplies for this use were limited and expensive, therefore, the use of reclaimed water was an acceptable alternative. The barrier would be close to the sewage treatment plant at Palo Alto, reducing the cost of supply pipelines.

A new 1.5 cubic meter per second activated sludge sewage treatment plant had been constructed and the old plant abandoned. Some of the facilities at the old plant were converted to become part of the reclamation facility. The constructed reclamation plant processes 0.2 cubic meter per second using high lime treatment and clarification, aeration for partial ammonia reduction, recarbonation using gases from sludge incineration, multi-media filtration, and activated carbon. Both ozone and chlorine are used for sterilization.

The effluent quality criteria was dictated by the need to inject the reclaimed water through wells into the underground confined aquifers. The injection water must have zero turbidity, be free of dissolved gases, and be sterile.

The underground hydraulic barrier was designed to maintain shallow aquifers pressure levels above the bay water surface, but not water log the local area. This required a line of injection wells parallel to the coast and a line of extraction wells inland of the injection wells. The extraction wells will remove saline water forced inland by the injection of freshwater. The extraction wells will also remove injected reclaimed water that would otherwise move inland. After reduction in salinity, the extracted water could be made available for reuse.

Additional water reuse includes irrigation of landscaping and a golf course. Market expansions include industrial reuse which would be primarily cooling and washing processes.

The reclamation facility is also being used for research on quality of water and automated water quality analysis. Automated real time quality analysis is being performed in cooperation with NASA and change in quality of injected water is being evaluated in cooperation with Stanford University. Planned further research includes computer control over chemical feed and process train selection based on real time water quality data. Currently, the plant is manually operated 8 hours a day and by computer 16 hours per day and 48 hours on weekends. The objection of the water reclamation facility at Palo Alto is to demonstrate reclamation plant reliability and water quality acceptability for all uses.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Planning the Location of a Municipal Wastewater Treatment Facility Upstream from a Municipal Water Supply Intake

AUTHORS: Patrick M. Tobin and George Wesner

AFFILIATION: U. S. Environmental Protection Agency, CWC Engineers

DATE OF SESSION: Monday, March 26 *SESSION NO:* 3

Indirect reuse of municipal wastewaters is a major concern when planning to site a wastewater facility upstream from a municipal water supply intake. There is a lack of raw water quality standards applicable to both polluted water supply sources and to relatively unpolluted sources on which drinking water regulations are said to be based. This lack of a uniform standard causes many uncertainties for water supplies downstream of wastewater discharges when such discharges constitute a significant portion of the supply. These uncertainties raised for indirect reuse of wastewaters appear to be of even greater concern when one considers the direct reuse of wastewaters for potable purposes.

In order to compare the effects of several variables that must be considered when evaluating water intake locations, a wastewater discharge - water supply intake model system was established. The system's variables included: (1) level of wastewater treatment, (2) separation time between the point of wastewater discharge and the water supply intake, (3) quantity of wastewater as a percentage of total stream flow, (4) level of water treatment, and (5) relative sizes of the wastewater and water treatment plants. In addition, the following quality parameters were examined: microbiological, turbidity, organic chemicals, inorganic chemicals and radioactive materials.

Separation time and potential health hazards from synthetic organic chemicals were found to be parameters of most practical importance. Three case histories involving decisions on the siting of wastewater treatment plants upstream of water supply intakes were examined.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Observations on the Start-up of the Water Reclamation - Recharge Project in Nassau County, New York

AUTHORS: James A. Oliva, Francis J. Flood and James S. Gillen

AFFILIATION: Nassau County Department of Public Works

DATE OF SESSION: Monday, March 26 *SESSION NO:* 3

I. History of the Project
  A. Introduction
    1. Location of Nassau County and need for recharge
    2. Past reuse-recharge project (purpose and results)

  B. EIS (1971-1972) Recommendation for reuse-recharge demonstration

  C. Study for the "Correlation of Advanced Wastewater Treatment and Ground Water Recharge, " (1972-1973)
    1. Recommendations and EPA approval/1974

  D. Federal Grant for Design and Construction
    1. R&D & Construction Grants (1975)

II. Design and Construction Phase
  A. Reclamation (Reuse) Plant, transmission main & recharge facilities
    1. Design (1975-1976)
    2. Bid period (1976)
    3. Construction (1977-1979)

III. Operation (1979-1984)
  A. Construction Delays

  B. SPDES Permit (Effluent Standards)

  C. Obtaining Personnel for Operations and Maintenance

  D. Obtaining Funding for Operations and Maintenance

IV. Schedule for First Year's Operation
  A. Debugging of equipment

  B. Training of Personnel

  C. Monitoring of Product
    1. Subcontracts - virus - Vaughn - trace organics

  D. Start-up Services - Consoer, Townsend & Associates

  E. U. S. Geological Survey - Operations - 1979

V. Future Operations 1980 and Beyond

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: OWRT's Water Reuse Research and Development Program

AUTHORS: Robert S. Madancy

AFFILIATION: Office of Water Research and Technology

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 4

The Office of Water Research and Technology (OWRT) was first authorized to conduct a comprehensive water reuse research and development program starting with U. S. fiscal year 1977. Approximately $1.7 million was authorized for this program in FY 1977 with an additional $3.3 million authorized for FY 1978 and $3.45 million for FY 1979. The OWRT Water Reuse Research and Development Program is oriented towards supplementing existing water supply sources and conserving limited water resources in order to extend the available water supply for the Nation.

The Program is focusing upon planned beneficial reuse of wastewaters from the following sources:

Municipal (domestic) Wastewaters.

Industrial Process Wastewaters.

Cooling Water.

Agricultural Wastewaters (Irrigation return flows).

Program priority is being given to support of research and development efforts for the following major reuse applications: groundwater recharge; industrial process water; industrial cooling water; aquaculture; irrigation; domestic reuse; and energy conservation. Industrial reuse research and development efforts are being focused primarily upon high water using industries such as: Paper and Allied Products, Chemical and Allied Products, Primary Metal Industry, Textile Mill Products, Petroleum and Coal Products, and Food and Kindred Products. R&D efforts for other industries are being considered, however projects for other industries must represent significant National potential. The OWRT Reuse Program is focused primarily on reuse and does not include efforts dealing primarily with pollution control with minor emphasis on water reuse.

Current treatment process R&D emphasis for reuse is on the adaptation of technology now being used for demineralization of brackish and seawaters. Research is also well underway in the "soft-sciences" aspects of water reuse including institutional, legal, social, and environmental barriers to reuse.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Wastewater Reuse Program at U.S.A.M.B.R.D.L.

AUTHORS: William J. Cooper

AFFILIATION: U. S. Army Medical Bioengineering R&D Laboratory

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 4

From a program designed to meet the needs of field medical facilities, the wastewater reuse program at the U. S. Army Medical Bioengineering Research and Development Laboratory has evolved into one to support the needs of the Army in the field and in fixed installations. In the process, the emphasis of the USAMBRDL reuse program has shifted from development of treatment processes to development of water quality criteria to protect the health and preserve the effectiveness of the soldier. The reuse program is divided into three project areas: water quality criteria, process engineering and analytical methodology. The current emphasis in water quality criteria is on non-potable reuse for the Field Army. Process engineering research is carried out in a pilot plant containing, in a flexible array, the range of practicable physical and chemical treatment processes and which is now integrated with an advanced wastewater treatment pilot plant employing biological treatment processes. Both of these treatment trains are supported by a computer system for monitoring and control. Analytical methodology includes the development of on-line and off-line methods for chemical and microbiological analysis, monitoring and control. This paper will provide a program overview and necessary background information on a number of papers which have come out of efforts supported by this program and are to be presented during the Reuse Symposium.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25—30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: EPA Research and Development Program for Water Reuse

AUTHORS: Stephen J. Gage

AFFILIATION: U. S. Environmental Protection Agency

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 4

The Office of Research and Development (ORD) conducts a comprehensive water reuse research program. This paper presents an overview of the program and describes the role that each of the key research laboratories have in implementing this program.

The research program focus is on developing and demonstrating technology that is capable of producing effluents from municipal and industrial wastewaters that can be recycled or reused in a beneficial or successive way. The program also emphasizes major research in health effects of potable reuse from municipal wastewater sources. A short summary of each laboratory (Municipal Environmental Research Laboratory, Industrial Environmental Research Laboratory and the Health Effects Research Laboratory) program will be presented and will include: (a) program objectives; (b) past program accomplishments; (c) current fiscal year 1979 program activities and funding; (d) future program with five year projection on where ORD expects to be and what knowledge gaps will be addressed.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: The National Science Foundation's Role in Support of Research Relating to Wastewater Reclamation and Reuse

AUTHORS: Edward H. Bryan

AFFILIATION: National Science Foundation

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 4

Since its establishment in 1950 as an independent agency of the executive branch of the federal government, the National Science Foundation (NSF) has provided support for research which has contributed toward a better understanding of scientific principles including those relating to the cycling of water on earth. Congressional action in 1968 authorized NSF to begin support of research applied and directed toward solutions to important national problems. The results of this research initiated during the first half of this decade will help in providing the basis for a more vigorous search for practical ways to solve the increasingly important problems relating to quality and quantity of water.

In addition to direct contributions that have led to better understanding of natural laws governing water, NSF's role has also been supportive of the directed efforts of those agencies charged specifically with lead agency responsibilities for some aspect of water management relating to their mission. Modifications of the Water Pollution Control Act (PL 92-500) with new emphasis on encouraging the evaluation of innovative concepts and the passage of the Water Research and Development Act of 1978 provide excellent opportunities for development and demonstration of promising concepts emerging from research. The lead agency responsibilities for implementation of this legislation rest with the Environmental Protection Agency and the Department of Interior's Office of Water Research and Technology, respectively.

The National Science Foundation's role in supporting research on wastewater reclamation and reuse is likely to be concentrated on those gaps in knowledge which despite their importance, are unlikely to be addressed by the mission agencies, state and local government or the private sector and where NSF can make unique contributions appropriate to and consistent with its other responsibilities.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Water Reclamation Efforts in California

AUTHORS: Kurt L. Wassermann and Jan Radimsky

AFFILIATION: California Office of Water Recycling

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 4

The potential of reclaimed water to help in meeting present and future water needs of California is obvious and recognized in current state laws mandating wastewater reclamation. Although reclamation is not a new concept in California, and many successful reclamation projects are in operation, only 8% of 2.4 MAF of municipal and industrial wastewater produced annually in California are reclaimed.

While a 1977 Policy and Action Plan did much to encourage and clear the way for reclamation, there was still a need for an entity with the specific responsibility of leadership and coordination of all activities recommended by the Policy and Action Plan. Governor Brown filled this need in October 1977 by creating the Office of Water Recycling (OWR) within the SWRCB. At the same time, the Governor established a five-year goal of constructing facilities that will make available an additional 400,000 acre-feet of reclaimed water per year by 1982.

To accelerate and encourage water reclamation activities, the OWR is performing several major functions:

- Organization and supervision of basinwide reclamation planning studies with the objective to identify new reclamation projects.
- Evaluation and administration of Clean Water Construction Grants for water reclamation projects.
- Identification and resolution of roadblocks to wider application of reclamation.
- Coordination of wastewater activities between federal, state and local agencies.
- Serving as the State's focal point for technical information exchange and public education in the area of water reclamation.

OWR activities focus on the three major volume uses of reclaimed water:

Agricultural and landscape irrigation; Groundwater recharge; and Industrial Reuse.

Current major activities and future plans for each of the major areas or reclaimed water reuse will be described.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Influence of the Clean Water Act on Water Reuse Planning

AUTHORS: Richard E. Thomas, Lam K. Lim, and Alan B. Hais

AFFILIATION: U.S.E.P.A. - Municipal Technology Branch

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 4

The Clean Water Act of 1977 requires grant applicants to analyze innovative and alternative technologies for use in wastewater treatment works after September 30, 1978. This requirement of the Clean Water Act and the legislative history of the Act makes it clear that the emphasis on innovative and alternative technologies is intended to achieve increased water reuse and recycling of nutrients. In the words of the Congressional Conference Committee report on the Clean Water Act, EPA "...has been provided all of the legislative tools to require the utilization of such innovative and alternative wastewater treatment processes and techniques." These innovative and alternative technologies emphasizing nutrient recycling, wastewater reuse in agriculture and industry, and energy recovery are to be given preference over conventional wastewater treatment technologies in the EPA program to abate water pollution.

This emphasis on implementation of innovative and alternative technologies will be implemented through provisions of the Clean Water Act which provide incentives and requirements for use of the innovative and alternative technologies in the EPA Construction Grants Program. This paper will discuss the projected influence of these incentives and requirements on the future of water reuse planning and implementation. The factors to be covered include: (1) financial incentives to stimulate more use; (2) requirements to spend a specific part of funds in fiscal years 1979, 1980, and 1981; (3) cost-effective allowances; and (4) new areas of eligibility. These factors will be covered from the perspective of the new law, the EPA promulgation of construction grant regulations, and the EPA issuance of program guidance for implementing the law and the new revisions to construction grant regulations.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: The Potential for Wastewater Reuse in the United States

AUTHORS: George M. Wesner, Mark V. Hughes, Jr.

AFFILIATION: CWC Engineers, Private Consultant

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 4

This paper describes a study recently completed for the Department of Interior, Office of Water Research and Technology on water requirements and the potential for wastewater reuse in the United States. The basic data on water needs and availability are based on information developed by the U. S. Water Resources Council for the recently completed Second National Water Assessment. Water requirements and availability, wastewater discharges and the potential for wastewater reuse are presented for each of the 21 Water Resources Council regions and 107 subregions. Eighteen of the regions are in the contiguous United States; the other three are Alaska, Hawaii and the Caribbean. The sources of wastewater and potential uses of reclaimed wastewater are divided into the following categories:

Wastewater Discharges	Wastewater Reuse Potential
Agricultural Irrigation	Agricultural Irrigation
Steam Electric Plants	Landscape Irrigation
Industry	Steam Electric (Cooling)
Municipal	Industrial Cooling
Fish Hatcheries	Industrial Other

The estimated total existing wastewater reuse in the United States is about 678 mgd or 760,000 acre-feet per year. Wastewater reuse currently takes place in 49 of the 106 Water Resources Council subregions in 536 locations. The largest volume usage is in California and Arizona and the greatest number of projects are in Texas and California.

The potential for wastewater reuse exceeds the available wastewater discharges. The requirements for agricultural irrigation alone exceed the total available wastewater discharges from all sources. Several factors will determine the quantity of wastewater that will actually be reused including the geographic location of dischargers and potential users and the availability and cost of alternative supplies. There are large regional differences in wastewater availability and reuse potential. In the eastern states and Alaska, quantities of available wastewater discharges and the potential for reuse are relatively in balance. In the western United States, the potential for reuse greatly exceeds the available wastewater. This difference is primarily due to agricultural irrigation, the major current, and future potential, reuse of wastewater.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: The Contra Costa Reclaimed Water Project

AUTHORS: John E. DeVito and John S. Gregg

AFFILIATION: Contra Costa County Water District

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 5

The Contra Costa Reclaimed Water Project is a cooperative venture between the Contra Costa County Water District and the Central Contra Costa Sanitary District. The project is in central Contra Costa County, California, adjacent to the San Francisco Bay Area.

The project, presently at the startup and testing phase, has a total estimated construction cost of about $80 million. When in full operation the facilities will provide pollution control through a 40 mgd secondary waste treatment plant, and produce up to 30 mgd of softened reclaimed wastewater for cooling use by industries.

Studies in the mid-1960's prompted the District to explore alternatives that would augment its water supply and extend the conveyance capacity of its import and transmission system, the Contra Costa Canal. The District studied desalting, groundwater, and wastewater reclamation alternatives. The Sanitary District had adequate wastewater and their facilities were located near the industries considered by the Water District as potential markets for reclaimed water.

With Federal and State Water Quality Legislation, it became necessary for the Sanitary District to plan for expansion and upgrading of its facilities. Water quality standards for discharge to the Bay were high, requiring a high level of treatment of wastewater. Both Districts would benefit if the treated wastewater could be re-used, the Sanitary District through revenue from sale of its effluent and the Water District by delaying enlargement of the Contra Costa Canal. Front end questions concerned the necessary institutional arrangements between the Districts, Department of Interior, Federal Water Quality Control Administration, State Water Resources Control Board, and the U. S. Bureau of Reclamation and with the reclaimed water customers.

Since finalizing those institutional arrangements and initiating design and construction, several events have altered the project.

- Reduction in Discharge Standard -- this resulted in the elimination of the denitrification process which in turn required changes in the Water District designs and renegotiation of the Agreement between the two Districts.
- The 1976-77 Drought -- this emphasized the need for a firmer supply and the advantages of re-use, however, quality degradation due to the conservation effort of water customers, which in turn reduces waste flow, poses new problems. Of particular concern is the relationship between the degree of efficiency of water use in the area sewered and the utility of reclaimed wastewater. Consideration of these relationships are being integrated into the District's planning efforts.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: An Evaluation of AWT Processes for Water Reuse in two Selected Industries

AUTHORS: Richard A. Osantowski and A. Geinopolos

AFFILIATION: Rexnord

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 5

In-depth pilot scale evaluations investigating the applicability of advanced waste treatment methods for renovating effluent from a paper mill and a food processing facility were performed. Effluent treated to levels by Best Practicable Control Technology Currently Available (BPCTCA) was then pumped through both pretreatment technologies and advanced treatment methods. The advanced treatment methods, both singularly and in combination which were investigated on the pilot basis included:

1. CT + DMF + RO
2. CT + DMF + AC + IE
3. CT + DMF + AC + ED
4. DMF

Key

CT - Chemical Treatment
DMF - Dual Media Filtration
RO - Reverse Osmosis
AC - Activated Carbon Adsorption
IE - Ion Exchange
ED - Electrodialysis

For each treatment train investigated, samples and operational data were obtained for later use in assessing and comparing the adequacy of the individual advanced waste treatment methods and establishing potential for reuse. The residual pollutants monitored included pH, temperature, suspended solids, BOD, COD, TOC, anions, cations, nitrogen compounds, color, and phosphorus.

The paper mill study was performed at a deinking mill which produced 150 tons of product per day. The food processing facility was a meat packing plant with a slaughterhouse. Both studies were performed on site using mobile pilot equipment designed to operate at a flow rate of 5 gpm. The pilot program extended two months at each location.

The pilot study data evaluation criteria include performance (effluent quality, residuals from treatment, operation and maintenance), costs (capital and operating), space requirements, and wastewater reuse potential. Comparisons were made between the water quality achieved from various treatment units and that required for reuse in various in-house processes.

The results showed that advanced treatment processes were quite effective in removing pollutants to low levels. Pretreatment with filtration and activated carbon reduced both suspended solids and organics. With proper pretreatment all three potential demineralization processes: ion exchange, reverse osmosis and electrodialysis, could produce a high quality effluent. However, the costs for treatment could be quite high, depending on the industry, feed quality and the treatment methods included. This project effort was funded by the Office of Water Research and Technology under contract number 14-34-0001-7805.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25–30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Total Water Reuse - Can Industry Afford it?

AUTHORS: Harold J. Kohlmann and Ivan Pouschine, Jr.

AFFILIATION: Hydrotechnic Corporation

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 5

There are many reasons industry is considering the reuse of water. Federal laws, environmental regulations and increasing water scarcity are probably the more forceful and immediate. In many cases, a number of technical problems have to be resolved before an optimum recirculation and reuse system can be designed and installed. Once a tightly bottled up integrated system is designed, it is a relatively easy task to incorporate it into a new plant. However, retrofitting recycle systems into old plants would require a careful survey of existing installations and the elaboration of several alternate approaches before the best one can be determined.

Implementation of a successful and economical reuse system requires a thorough knowledge of the industry in question, its operational procedures, its limitations and problems. The constraints of a particular plant must be taken into account. If these criteria are not met, the system installed can prove to be defective. There are instances of costly "white elephants" which are only marginally successful. Advance technology must be utilized where applicable, but pioneering must be prudent where new fields are plowed. Evaluation of the available choices must be based on experience, and pilot plant testing may be required.

This paper covers generalized systems for the reuse of water in industry, and also describes processes that have a specific application for a particular manufacturing sector.

Ongoing studies by Hydrotechnic, one for the U.S.E.P.A., on "Zero Discharge of Water from Integrated Steel Plants" will be completed by the conference date; and another for the OWRT, "Study of Potential for Water Conservation and Reuse in the Steel Industry," which is in progress, will be discussed. The general conclusions reached, as well as evaluations of economic, technical, energy and environmental factors are presented. This will provide a basis for reviewing the water requirements and pollution control problems of other industries and for presenting areas which require further research. An overall assessment of water reuse on a national basis is included.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25-30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Industrial Reuse of Wastewater; Cost Analysis and Pricing Strategies

AUTHORS: Gordon P. Treweek, R. Rhodes Trussell, Katherine P. Fox

AFFILIATION: James M. Montgomery Engineers

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 5

Although many of the technological barriers to the implementation of industrial reuse systems have been solved, industrial reuse of reclaimed wastewater still represents only a small fraction of water reuse. This is disturbing in view of the fact that industrial water withdrawals in California and the United States are the largest single usage category next to agricultural irrigation. The research conducted under the auspices of the Office of Research and Technology identified specific users of industrial water in the Southern California area, particularly the high volume users of evaporative cooling tower water and determined cost functions applicable to the user and the appropriate water purveyor. A principal interest in this research was to define the cost of using waters with various levels of dissolved solids, scaling materials, and corrosive ions, these being the major determinants of user damages associated with the use of reclaimed water. In order to define the cost benefits to participants we identified the various user categories in relation to the cost associated with different quality criteria and different individual user problems, such as scale formation, condensate contamination, corrosion and heat transfer efficiency.

The research problem undertook a definition of the economic trade-offs involved in the widespread implementation of industrial wastewater reuse. The problem of industrial reuse of wastewater centers on the key issue of cost, how they are optimized, among whom they are allocating, and ultimately the pricing strategy required to make most effective use of this resource. A computer program was develped to cost the treatment range required to provide water of quality acceptable to the user. The program then developed a cost of delivering this water on site to the user. Following development of computer model, case studies were investigated so that direct recommendations could be made regarding industrial reuse. The paper presents the results of the analytical efforts to define the user cost for wastewater renovation and reuse.

Industrial reuse offers several features that make it relatively attractive compared to other uses. Because industries are often concentrated in areas with large volumes of domestic wastewater generated, and a few users consume high volumes of water, many of the problems of distribution are minimized. Because of localized high volume uses, public access to renovated wastewaters can be controlled and the possibility of cross contamination in potable supplies eliminated.

In summary, the paper describes the four major areas of interest under this research. First, we define the water quality parameters of principal importance and chose the optimal technology to achieve those parameters. The users cost was determined as a function of the wastewater quality and the desired water quality. Second, we developed an analytical model which evaluated the cost of transporting the reclaimed water to the water purveyor. This had the additional benefit of expanding the water supply while eliminating disposal needs. Third, the results of the water quality analysis and the analytical model were applied to case studies and potential wastewater utilizers in the Southern California area. Finally, a discussion is included which makes recommendations to the applicability of the model as a management tool in identifying users and allocating costs.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: The Effect of EPA Guidelines on Industrial Water Reuse

AUTHORS: George C. Cushnie, Jr.

AFFILIATION: Centec Corporation

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 5

Because increasingly stringent effluent guideline limitations are forcing industry to implement advanced abatement measures, the alternatives of reuse technologies are becoming more attractive. The economics of waste treatment make water reuse a necessity, since methods of waste treatment cannot even be considered unless water usage is reduced. As an alternative, water reuse technologies can reduce overall treatment costs by eliminating certain waste streams, reducing capital investment for treatment facilities and reducing operating costs, including energy. Additionally, some reuse technologies allow for the recovery of valuable process chemicals and by-products. Technical factors also make water reuse an important alternative. In general, the types of limits imposed by the EPA are expressed in pounds per unit of production. Through water reuse and flow reduction, the degree of waste treatment can therefore be reduced while limitations are still met. For many industries, the best practicable control technology (1977) and moreover the best available technology (1983) force common in plant abatement measures, including the reuse of process waters, plus end of pipe treatment. Therefore, water reuse can be expected to be an integral part of the pollution control scheme. Further, the 1977 Amendments to the Clean Water Act provide an extension of the best available technology until July 1, 1987, if an innovative production process can be utilized to result in a significant effluent reduction.

This paper examines these impacts and other repercussions of the guidelines upon industrial point sources. As a basis for the discussion, a brief summary of pertinent sections of P.L. 95-217, the Clean Water Act of 1977, will be provided. The discussion will emphasize both direct dischargers and those that discharge to publicly owned treatment works. Consideration will be given to toxic pollutants, nonconventional pollutants, conventional pollutants, the various levels of effluent control, and best management practices.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Reuse of Reclaimed Fruit Processing Wastewater

AUTHORS: 1) Larry A. Esvelt, 2) Harold W. Thompson, and 3) Herbert H. Hart

AFFILIATION: Esvelt Environmental Engineering, USEPA, Snokist Growers Cannery

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 5

Reclamation and reuse of wastewaters by food processing plants holds the potential for reducing the effluent emission rate to our surface waters and the environment and for reducing the water consumption to a fraction of previous levels. Before effluent reuse can be implemented on a broad scale, it must be demonstrated that there would be no adverse affects on food quality resulting from such an application of technology. It is necessary that the agencies responsible for regulating food safety and quality as well as those involved in the regulation of pollution emissions evaluate the data and approve implementation throughout the industry. The practicality and economic achievability of wastewater reuse must be evident to plant owners before implementation will be realized.

A two-year study at Snokist Growers' Cannery in Yakima, Washington applied low cost technology to reclaim their biologically treated effluent for reuse as a portion of the cannery's water supply and determined the feasibility for meeting a given reclaimed effluent quality. The technology consisted of multi-media filtration and chlorination and demonstrated that the reclaimed water could meet the following criteria: Suspended solids, 30 mg/l; Turbidity, 20 NTU; Coliform Bacteria, Less than 1/100 ml; Fecal Coliform Bacteria, Less than 1/100 ml; Total Plate Count, Less than 500/ml.

The reclaimed effluent was reused in pilot scale demonstration for 1) direct contact container cooling, 2) raw fruit transport and cleaning, 3) peeler and belt washdown, and 4) steam generation for equipment washdown, product cooking and product blanching. The reclaimed water was regularly used for floor and gutter washdown purposes over two seasons of investigation. There was no indication of adverse affects on the product quality or safety during these pilot scale runs.

A committee comprised of representatives from the Food and Drug Administration Division of Food Technology, the USDA Fruit and Vegetable Quality Division, the EPA Health Effects Research Laboratory, the EPA Industrial Environmental Research Laboratory, the National Food Processors Association and the principal investigator and project manager was convened for this project to analyze the results. They approved the conclusions and recommendations of the study which included statements that 1) The wastewater can be polished to a quality suitable for reuse within the cannery; 2) Neither the quality nor the safety of the final product is adversely affected by the use of the reclaimed processing water; and 3) Toxic constituents tested for were not present in the reclaimed effluent in concentrations sufficient to cause public health concern for the final products. The committee recommended that the cannery proceed with a full-scale demonstration of reclaimed water use in the area of direct contact container cooling, initial product conveying and washing, and washdown for equipment and surfaces which do not contact the peeled and processed fruit. They recommended that a more extensive investigation program be designed to determine levels of toxicants such as pesticides, heavy metals and halogenated organics and that the study be conducted over a two-year period. Deliberations are presently under way to obtain funding for the demonstration program.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25–30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Regional Water Reuse in Southern California - from Marketing to Implementation

AUTHORS: F. Wiley Horne and Gary J. Hazel

AFFILIATION: Orange and L.A. Counties Water Reuse Study

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 6

State and Federal water quality legislation of the 1970's has brought about an unprecedented construction of advanced wastewater treatment facilities in the Orange and Los Angeles Counties metropolitan area. In order to comply with the State's stringent stream discharge requirements, more than 125,000 acre-feet per year (AFY) of tertiary-treated reclaimed water is now being produced, and an additional 80,000 AFY is planned for the mid-1980's. About one-third of the water is now being reused, the remainder is being discharged to the Pacific Ocean.

The high cost of providing advanced treatment has made the reclaimed water too valuable to waste to the ocean. The tertiary-treated water is highly-clarified, thoroughly disinfected, and essentially virus-free. The volume of flow is large, comparable in quantity to the planned yield of new surface reservoirs in Northern California.

California's statewide drought and water shortage of 1976-77 demonstrated an immediate need to actively market reclaimed water on a large scale as a supplemental water supply to serve appropriate uses. Six regional water suppliers and wastewater managers have joined together, in cooperation with the State of California and EPA, to establish marketing and financial arrangements for expanded reuse.

The presentation will describe the reclamation plants, available reclaimed water, prospective reuse applications, arrangements with water purveyors to offer reclaimed water as a new class of service, preliminary engineering plans, and joint State-local financial plans. The significance of the Study is that, for the first time, water reuse is being planned, financed and constructed as an integral element of a State's water development strategy, on the same basis as surface reservoirs or other conventional water supplies.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: A Study of Aquifer Recharge by Direct Injection of Highly Treated Sewage Effluent - El Paso, Texas

AUTHORS: Daniel B. Knorr

AFFILIATION: Parkhill, Smith and Cooper, Inc. Engineers

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 6

During the past year the author, as a consulting engineer for the City of El Paso, Texas, has been involved in feasibility studies relating to the direct injection of sewage effluent treated to potable water qualities into a fresh water aquifer used for the city's water supply. The overall objective of the work is to add a long term fresh water resource to the City of El Paso's dwindling supplies. The paper would describe the general nature of the project with specific information on need, effluent limitations, process selection, treatment costs, and pilot plant data.

The general nature of the project such as size (10 MGD), alternate water resources, aquifer location, and potential for increased application of the recharge technique will be discussed. Data relating to the aquifer, injectivity tests, injection well design, injection and production well spacing and injection program control will be discussed in general terms based upon a detailed U.S.G.S. study currently underway. A short discussion of energy recovery in the injection wells will be included.

The preliminary design of the treatment plant process and the design criteria will be discussed. A two month influent sampling program involving daily sampling of 31 parameters and spot analysis for trihalomethanes and synthetic organics resulted in the influent design parameters. The water supply and sewage effluent are compared to determine analysis changes through the use cycle.

Effluent (potable water) criteria used in the plant design was based upon the EPA and Texas Department of Health Drinking Water Standards including proposed standards in addition to well plugging criteria. Additionally the plant will have no point of discharge other than to recharge, thus reliability is an extremely important criteria.

The process design was based upon reliability, costs and effluent quality. The processes were evaluated considering several general treatment requirements including primary treatment, carbonaceous removal, nitrogen removal, metal removal, phosphorus removal, residual organic removal, disinfection and TDS removal.

The process selected is one utilizing primary treatment, equalization, two stage PACT, high lime, recarbonation, filtration, ozonation, GAC filtration and residual chlorination. Although no piloting has been done to date, plans call for piloting to be done on the PACT process during the last quarter of 1978.

The objectives of the piloting are to determine: residual organic removals, methanol dosages related to both effluent nitrogen and organics, alkalinity changes, lime and CO_2 dosage of effluent. The results of this piloting should be available for the paper.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Guidelines for Implementing a Program for the Reuse of Municipal Wastewater Effluents
AUTHORS: Paul W. Prendiville

AFFILIATION: Camp, Dresser & McKee, Inc.

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 6

Environmental Protection Agency (EPA) has identified an immediate short-term objective of developing a wastewater-reuse guidelines document that will significantly increase interest in and assist implementation of wastewater reuse for nonpotable purposes: irrigation and agriculture, industrial, recreation, and nonpotable domestic use. The guidelines, now being developed, will make water managers and resource planners aware of proven reuse possibilities that may exist nearby and will alert the guidelines' user to EPA's encouragement and support for this approach.

Following a step-by-step approach provided in the guidelines, the water manager and resource planner have addressed the principal areas of concern in water-reuse programs, including economics, legal issues, institutional arrangements, and public information. The nature of these areas of concern are examined so that the guidelines user can estimate the complexity of the implementation problem and the effort required to overcome it. Case histories provide insight into actual reuse experience for similar communities. The result to the user of the guidelines is a clear indication of the feasibility of wastewater reuse in the community.

The introduction to the guidelines is designed to show that water reuse may represent an effective problem-solving measure for a community or region. The guidelines user is led through a flow sequence diagram that shows how the guidelines can be used to establish the viability of reuse on a case-by-case basis.

The following issues are addressed in subsequent chapters:

Identifying sources of reusable water.
Identifying water reuse application.
Inventorying water use and cost for potential users.
Estimating transportation and storage costs.
Water quality requirements.
Pretreatment costs.
Determining cost allocation and user charges.
Institutional, legal and financial considerations.
Identifying health agencies and procedures.
Marketing the resource.
Dependability requirements.
Identifying financing mechanisms.
Public information.
Implementing a program.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Wastewater Reclamation for the San Francisco Bay Region

AUTHORS: John S. Harnett and Philip G. Hall

AFFILIATION: East Bay Municipal Utility District and CH$_2$M-Hill Engineers

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 6

California's recent 2-year drought, plus projected shortages in the State's water supply, have led to renewed interest in reuse of reclaimed wastewater. Reuse of wastewater from the San Francisco Bay Area is especially attractive. The 4.5 million residents of the Bay Area use high-quality water imported from the Sierra Nevada Mountains so that the resulting wastewater is also of relatively high-quality, particularly after increasingly stringent discharge requirements are met. In addition, the wastewater now discharged into San Francisco Bay or the Pacific Ocean is being lost from the freshwater resources of the State. Reuse of Bay Area wastewater will help preserve these resources by extending the time before new conventional supplies must be developed and by reducing quantities of imported water.

All the major potential reuse markets were studied and analyzed quantitatively. These markets comprise agricultural use (primarily involving nonfood chain crops), powerplant cooling, and flow augmentation in the Sacramento-San Joaquin Delta.

Powerplant cooling water is a major potential market because Pacific Gas and Electric is proposing construction of a coal-fired powerplant to meet the growing power demands of the Bay Area.

Water for flow augmentation in the delta would provide an alternative means of preventing increased intrusion of saltwater from San Francisco Bay into the agriculturally rich interior delta. Under current agreements, the State Department of Water Resources and the U. S. Bureau of Reclamation must release large quantities of freshwater to prevent salinity intrusion. If reclaimed wastewater were used for this purpose, more freshwater would be available to reduce shortages to users of the State Water Project and Central Valley Project. The major concern is the potential for pollution of the delta and San Francisco Bay.

Several constraints on the reuse of reclaimed wastewater have been identified and evaluated. These include regulations of the State of California Health Department, funding availability for large-scale reclamation projects, and fair assessment of costs and benefits.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Wastewater Reuse Alternatives at Lake Tahoe

AUTHORS: Gordon L. Culp, Russell L. Culp, Daniel J. Hinrichs, and Robert B. Williams
AFFILIATION: Culp/Wesner/Culp Engineers

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* 6

A study of various alternative water reuse alternatives is described. The study compared continued reuse of advanced waste treatment (AWT) process effluent in a recreational reservoir and subsequent irrigation with the use of secondary effluent for pasture irrigation. The use of a system involving use of secondary effluent in an existing flood irrigation system was found to be substantially lower in cost than continued use of physical-chemical AWT (tertiary) processes. Total costs were reduced by about 27% (when compared to the lowest cost AWT approach) and local costs by about 40%. Energy conserved by the treatment process consumption would be reduced by 50%, and the energy required elsewhere to produce chemicals and materials consumed in treatment would be reduced by 80%. Although the potential cost savings are significant, implementary reuse of the secondary effluent may be difficult because implementation is dependent upon gaining the political acceptance of the concept by a County which has rejected such proposals in the past. The current status of the implementation program is described.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: An Integrated, Controlled Environment Aquaculture Wastewater Treatment System in Hercules, California
AUTHORS: Christopher R. Alsten, Steven A. Serfling, and Dominick Mendola
AFFILIATION: Solar Aqua Systems

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 7

The City of Hercules, thirty miles northeast of San Francisco, California, is beginning construction of an ecological-aquaculture type wastewater treatment and reclamation facility capable of converting domestic sewage into high quality reclaimed water, and recycling 100% of the nutrients, aquatic plants, invertebrate fauna, and sludge into reusable by-products. The facility is expected to begin operation by January, 1979 (six months from start of construction.)

The treatment process centers around an innovative, aerated lagoon design known as the Solar AquaCell System, which utilizes 1) greenhouse-type solar pond cover over an 8' deep pond for maintaining higher year-round operating temperatures and transferring solar heat; 2) floating aquatic macrophytic plants (e.g. water hyacinths and duckweeds) for reduction of BOD, suspended solids, dissolved nutrients, uptake and metabolism of organic chemicals and heavy metals; 3) submerged, fixed-film, biological substrates ("Activated Bio-Web") to increase surface area for bacterial, protozoan and invertebrate food web productivity; 4) dual submerged and surface aeration systems for mixing and oxygenating the pond; and 5) hardy, invertebrate grazing organisms for consuming, metabolizing, and bio-concentrating particulate waste, detritus, and bacteria. Fish can also be raised in the second stage of the pond to act as the final step in the food chain process.

For the Hercules project, pre-treatment will consist of a grinder, followed by a solar-heated, anaerobic tank with floating cover for primary treatment and sludge digestion. Post treatment using sand filtration and ozone disinfection will follow the AquaCell lagoon to ensure high quality water as needed for industrial reuse.

Because the reclaimed effluent will be of near potable quality, multiple reuse application will exist. Two local industries have expressed a desire to purchase the water for process operations. Greenbelt and forage crop irrigation needs exist within the community, and two creeks, often dry most of the year, are suitable for enhancement and/or incorporation into a marsh-wildfowl sanctuary.

The aquatic plants will be harvested weekly and converted into a rich organic compost. Digested sludge from the primary treatment digestion tank will be composted together with the harvested plants to improve the composted sludge texture and dilute any potentially toxic concentration of heavy metals to safe levels for garden use. In future years, conversion of aquatic plants and sludge into methane gas to replace electrical aeration energy will be considered.

The possibility of culturing salmon fingerlings in the AquaCell lagoon to feed on the abundant invertebrate fauna will also be considered in the future. Salmon fry would be released to swim down the creek enhanced by reclaimed water, out to the Pacific, and return 2 - 3 years later as a private run to the backyards of local residents bordering the stream.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Recycle and San Diego

AUTHORS: Richard W. King

AFFILIATION: City of San Diego

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 7

While the population of the City of San Diego is just under 800,000, the surrounding area of the hydrological basin including Tijuana, Mexico has about 2,300,000 people. This is expected to double in the next 20 years. There is sufficient rainfall to support 35,000 inhabitants, which translates into finding an adequate water supply as the major problem facing the area.

San Diego's sewage is 95% domestic, having less heavy metals in it than some other cities' secondary treated effluent. Because the ocean has 15 times more salt than does sewage, recycle of effluent as a potable source is simpler to do. In recycling effluent, San Diego would not only comply with Public Law 92-500 but would provide an answer to its water source as well.

Because of its location, San Diego lends itself to new aquaculture technologies especially water hyacinths as researched by NASA. Recognizing this potential coupled with conventional screening pretreatment and concluding with reverse osmosis that the City continue to research, could develop a superior water. In addition, other sewage ingredients can be converted into a useful purpose as for food and energy making the entire approach one of resource recovery rather than throwing away or concentrating pollutants to possibly harmful levels as is customarily done. Such a program is underway for grant funding a 1 mgd plant, for a 3 year study period and costing $3,500,000. If the program is successful, the result would be a combined water and sewer system that takes less electrical energy and is less costly to the home owner than any other idea yet developed.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Reclamation and Reuse of Wastewater in the Suisun Marsh, California

AUTHORS: W. Martin Roche and Norman Cederquist

AFFILIATION: U. S. Bureau of Reclamation

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 7

The U. S. Bureau of Reclamation in cooperation with the City of Fairfield and the Solano Irrigation District are investigating the feasibility of using wastewater in the Suisun Marsh of Solano County, California. From 1975 to 1978, the Water Quality Branch operated a pilot demonstration program using seasonally nitrified effluent from the City of Fairfield's Cordelia waste treatment facility. The program was designed to provide information on the reuse of wastewater for management of brackish water waterfowl habitat and for agriculture irrigation and provide the Bureau with information on using wastewater as a source of water for meeting its responsibility for protection of the integrity of the marsh.

Field facilities included a storage reservoir, a sprinkler irrigated tile-drained pasture, marsh ponds and flooded marshland. The study program was designed to determine the extent of nitrogen and phosphorus removal in the units, the potential for algae growth, the production of waterfowl and livestock forage crops, and information as to the quality of water discharged to waterways in the marsh.

Study results have shown that up to 90 percent of ammonia and nitrate nitrogen and 50 to 90 percent of phosphorus can be consistently removed in the tile-drained pasture return flows and a combination of 2 to 3 foot (0.6 to 0.9 meters) deep marsh ponds and shallow seasonally flooded marsh ponds growing waterfowl forage grasses.

The salinity of tile drainage decreased from 25,000 to less than 9,000 milligrams per liter total dissolved solids, and the groundwater was maintained at a minimum of 20 inches (50 centimeters) below ground surface. Inorganic nitrogen and total phosphorus in the tile drainage were always less that 1 mg/l respectively, even with application of up to 12 inches (30 centimeters) of wastewater per month.

Filamentous algae and pondweed growth was excessive during July and August in the permanently flooded ponds, and it was concluded that the operating depth of permanently flooded ponds, and it was concluded that the operating depth of permanently flooded ponds probably should be 5 to 6 feet (1.5 to 2 meters). There were no problems during other months or in the shallow irrigated "grass" marsh ponds. Inorganic nitrogen was reduced from 12 mg/l to less than 3 mg/l and phosphorus from 6 to an average of 3 mg/l in water flowing through the ponds.

The program was expanded in 1978 to a 5-year study of the use of wastewater from the new Fairfield subregional treatment plant on three duck clubs with a total of about 650 acres (263 hectares) of ponds. The extended study will monitor changes in vegetation, soil salinity and the amount of water needed seasonally to operate duck ponds in the Suisun Marsh.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: State-of-the-Art of Water Recycling in Fish Culture Facilities

AUTHORS: James D. Caufield

AFFILIATION: UMA Engineers, Inc.

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 7

This paper sets forth the current State-of-the-Art of recycling water in fish hatcheries in order to increase production over levels attainable with available fresh water supplies. A summary of basic and applied research leading to the present stage of development is provided. General recycle equations are tabulated. Examples of full-scale operational hatcheries with flows to 15,500 gpm are cited. Water treatment components are described. Flow diagrams and general cost data are included.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25–30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: A Combination of Aquatic and Terrestrial Ecosystems for Maximal Reuse of Domestic Wastewater

AUTHORS: Darrell L. King and Thomas M. Burton

AFFILIATION: Michigan State University

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 7

The Water Quality Management Facility (WQMF) at Michigan State University, is a research and demonstration facility for municipal wastewater recycling research. This facility consists of four 1.8 m deep lakes ranging in size from 3.2 to 5 ha with a total surface area of 16 ha. These lakes are coupled with a 58 ha spray irrigation site which is surrounded by a 72 ha aerosol buffer area. Secondary municipal wastewater can be spray irrigated on the land directly from the activated sludge facility in East Lansing, Michigan, or from any of three different depths from any of the four lakes or from any combination of lake water and secondary effluent. Primary effluent can be utilized for research purposes and will be investigated after current work on secondary effluent is completed.

Data from the WQMF lakes indicate that phosphorus reduction decreases markedly once benthic sediments are saturated but that excellent nitrogen removal continues. Harvest of aquatic plants results in removal of about 10% of incoming nitrogen and phosphorus. Aquatic plant growth in the wastewater lakes leads to accelerated denitrification during periods of plant senescence and decomposition. During active growth periods, aquatic plants increase pH to 10 or more causing large ammonia losses to the air.

Data from the spray irrigation site suggest that properly managed perennial plant systems such as those typical of oldfields or many forage crops take up enough nitrogen in plant biomass to remove 80-90% of the nitrogen applied in wastewater if these plants are harvested. Annual row crops and late successional forests are less effective.

The characteristics of the lakes and land sites of the WQMF suggest that the system can most effectively be operated as a combined lake-land system for treatment of 1892 m^3/day of secondary effluent on a year round basis. Data from the site has demonstrated that spray irrigation is feasible during the winter, but that nitrate leaching is a problem if high nitrate water is applied. Excellent phosphorus reduction is achieved throughout the winter. Thus, high nitrate secondary effluent is applied directly to the land throughout the summer when plant uptake is active. During the winter, lake water is applied from the outlet of the first of the four lakes until nitrate concentrations approach the drinking water standard of 10 mg N/liter, then application is from the outlet of the second lake until 10 mg N/liter is reached, then from the outlet of the third and finally from the outlet of the fourth lake. The lakes are filled to their maximum 2.4 m depth during the spring runoff period when irrigation is not feasible. Hydraulic calculations suggest that the 16 ha of lakes and a 25 ha spray irrigation site will be adequate for treatment of 1892 m^3/day (0.5 MGD) of secondary effluent on a year round basis and will result in substantial recycling of many of the nutrients in the wastewater and will recharge the groundwater with potable quality water. This system and our experience with it will be described in detail.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Wetlands Creation Using Secondary Treated Wastewater

AUTHORS: Francesca C. Demgen, J. Warren Nute

AFFILIATION: Mt. View Sanitary District, J. Warren Nute Engineers, Inc.

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 7

In 1974 Mt. View Sanitary District of Contra Costa County, California began a wetlands creation project consisting of applying secondary treated wastewater to 3.2 ha (8 ac) of low saline land. Research to date has consisted of physical, chemical, and biological analysis. Defining the system's components has been a major goal: lists of animal, plant, bird and invertebrate life have been compiled; analyses of the two created areas and the receiving water, a shallow slough tributary to Suisun Bay, has been undertaken. The information obtained has been incorporated into the design of three additional wetlands areas covering 4 ha (10 ac).

An average of 2271 m^3/d (.6 MGD) is treated in the plant and passes on to the marsh system.

Over a period of a year, biweekly analyses were done at seventeen stations in the marshes and slough, which receives the discharge. There has been no problem with blue-green algae, algal mats, or filamentous algae in either marsh. Algae growth is cyclical. The shallow depth and frequent wind mixing keeps the water evenly oxygenated.

The wetlands serve a dual purpose, habitat creation and some tertiary treatment of the effluent. Multiple habitat types have been created: i.e. shallow ponds, marsh, and a low bush land habitat formed by the perpheral vegetation. There are more than 68 species of plants consisting of emergents, field annuals and perennials, shrubs, grasses, and trees. At least 84 species of birds utilize the area: waterfowl, shorebirds, and passerine species. Shorebirds and ducks use the wetlands as a resting place during migration.

Techniques of wetlands management have been developed during the project. Mosquito breeding has been kept under control by keeping circulation patterns open and maintaining a plentiful stock of *Gambusia afinis* (mosquito fish) in the water. Circulation, depth control, and removing floating detritus are key elements of the waterfowl botulism (*Clostridium botulinum*) prevention program. The wetlands have had no known cases of avian botulism. Vegetation management has been accomplished through manual and mechanical removal as well as by variable water depth.

A balanced aquatic ecosystem has been created using secondary treated wastewater. It is low in both capital and energy costs. The project has been constructed at a cost of $130,000 for 7.2 hectares of marsh. The pond-marsh system operates by gravity, thus there are no pumping costs. It not only provides wildlife habitat but also recreational and educational values. Local birdwatchers, nature photographers, school groups and researchers all utilize the area. During 1977, 676 manhours were spent by visitors to the wetlands. The system provides seasonal tertiary treatment of the water through reduction of BOD and suspended solids, and year around removal of residual chlorine and nitrates.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Potential of Aquaculture for Reclamation of Municipal Wastewater

AUTHORS: William R. Duffer and Curtis C. Harlin, Jr.

AFFILIATION: U.S.E.P.A. - Kerr Laboratory

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 7

Wastewater aquaculture is very broad in scope involving a variety of organisms, both freshwater and marine environments, organized treatment processes, and wastewater recycling by inputs into natural aquatic habitats. Research needs and potential for utilization of the aquacultural alternative for reclamation of wastewater are discussed in relation to current technical progress for major areas of wastewater aquaculture. These areas include aquatic macrophytes, wetlands, aquatic invertebrates, finfish, and highly structured or integrated systems.

The technology base available for aquaculture systems that place primary emphasis on obtaining a valuable product is much greater than the technology base available for systems that emphasize the culture of aquatic organisms for wastewater treatment and management. Several types of aquacultural systems which are oriented toward production have been developed to the point that they are considered to be in the advanced demonstration or application stage. Wastewater aquaculture is a relatively new field of endeavor in the United States with most areas belonging to the earlier conceptual or exploratory phase. Technical progress is sufficient, however, in a few areas to warrant proceeding with developmental activities in order to establish process design criteria.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25–30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Studies on Water Reuse in the Netherlands

AUTHORS: 1) Jiri Hrubec, 2) B.C.J. Zoeteman, 3) Jan C. Schippers

AFFILIATION: 1&2) National Institute for Water Supply, 3) KIWA

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 8

From a hydrological point of view the Netherland belongs to the countries in the world with the lowest annual quantity of rain water available per inhabitant. However, severe water shortage problems are prevented by the import of large quantities of water from the Rivers Rhine and Meuse. Unfortunately these rivers collect water from some of the most industrialized areas in the world, populated by some 50 million persons. The national water supply system therefore has to rely to a large extent on water sources which contain a relative high proportion of potentially toxic chemicals to reduce the health risks as well as the environmental damage resulting from this situation; programmes are studied to improve water recycling in industry as well as reuse of carefully treated wastewater for non-potable and eventually potable purposes in households. To quantify present risks, involved in the indirect reuse of municipal and particularly industrial wastewater and to study additional technology and monitoring procedures a pilot-plant investigation has been started at Dordrecht. In this pilot plant biologically treated municipal sewage of Dordrecht city is further purified till drinking water quality by two treatment systems, one with and one without a desalination step. The treatment process including reverse osmosis has been operational since beginning of 1978 at a capacity of 1.5 m^3/h while the other system will be fully operational in the beginning of 1979.

Details of the reverse osmosis plants, optimization of the treatment systems and operational conditions are presented.

The results of the effects of different treatment steps as well as a detailed description of the detected levels of bacteria, viruses, inorganic and organic contaminants will be discussed. Preliminary results of in vitro mutagenicity screening tests for the product water are evaluated against the background of data for actually distributed drinking water, derived from the Rhine River.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Dan Region Project in Israel: From Laboratory Experiments to Full-Scale Wastewater Reuse

AUTHORS: E. Idelovitch, T. Roth, M. Michail, A. Cohen, and R. Friedman

AFFILIATION: TAHAL - Water Planning for Israel, Ltd.

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 8

In Israel, where natural water is scarce, municipal wastewater from medium and large cities is considered a valuable source of supply that should be purified adequately and integrated within the national water supply system. Several wastewater reclamation schemes have been planned and partly implemented in the last decade. The largest and most advanced of these is the Dan Region Project, which provides for advanced treatment, groundwater recharge and reuse of municipal wastewater from the Tel Aviv Metropolitan Area.

The Dan Region Sewage Reclamation Project was conceived about two decades ago. Extensive laboratory experiments and pilot-scale studies were carried out prior to the operation of the full-scale project (Stage One) in January 1977.

The changes in the conceptual approach to municipal wastewater reuse and in the treatment scheme itself, which have accompanied the project development, will be reviewed in the introduction to the paper.

In the First Part of the paper, some of the process results obtained in the pilot-scale and in the full-scale operations will be reviewed, and an analysis will be made of the major changes that the basic treatment processes have undergone from the preliminary small-scale experiments carried out in the laboratory to the full-scale operation, through pilot plant studies.

In the Second Part of the paper, the merits of indirect reuse via groundwater recharge will be examined. The advantages of intermittent spreading over continuous flooding for maintaining high infiltration rates will be discussed and the purification effects of the soil-aquifer system will be briefly reviewed, based on pilot-plant studies and full-scale operation results.

In the Third Part of the paper, the additional research and development work carried out in connection with the Dan Region Project in the last five years will be reviewed. The objectives of this work have been: to improve operations and results, to optimize the whole scheme, to increase the capacity of the existing installations and to reduce costs. Most of these processes have been studied in laboratory and at pilot-scale; some of them will presumably be adopted in the future for full-scale operation, either in the Dan Region Project itself or in other reclamation schemes.

The paper will conclude with a review of the technical and administrative difficulties involved in the implementation and operation of a large wastewater reuse scheme.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Development of Two Sewage and Solid Waste Treatment Systems with Potential for Water Reuse and Energy Recovery
AUTHORS: Duncan K. Smith and Richard V. Laughton

AFFILIATION: Ontario Research Foundation - Canada

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 8

The Ontario Research Foundation (ORF) has been actively involved in the development of two different wastewater treatment systems designed to renovate wastewater to a quality suitable for reuse.

One system is designed for military use as an Environmental Service Module (ESM) and the other for domestic application as part of an integrated waste management system called CANWEL (Canadian Water Energy Loop).

The military ESM is an air-transportable, combined wastewater purification, solid waste disposal system complete with facilities for 100 - 200 men for operation in the north. The process which employs wet air oxidation, reverse osmosis and ozone-UV oxidation is designed to treat all solid wastes (garbage) and human wastes (sewage) and produce a residue which is sterile, compact and may be disposed of relatively easily and safely. Extensive water recycling (80%) is employed for purposes other than drinking and culinary use.

The CANWEL system employs biological nitrification-denitrification, phosphorus removal, ozone disinfection and reverse osmosis steps for wastewater renovation. A starved air incineration method for disposal of garbage, surplus sludge and brine disposal is employed with heat recovery. The system has been designed to treat all liquid and solid wastes from a community of 500 to 1000 people to a degree where liquid and gaseous discharges from the system will exert a minimum load to the environment. The degree of purification achieved will permit reuse of water for utility purposes.

Highlights of both systems, typical applications and the results of bench, pilot and demonstration test programs conducted to date are discussed.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Wastewater Reclamation and Reuse Activities in Australia

AUTHORS: Michael A. Smith

AFFILIATION: Ministry of Water Resources and Water Supply - Melbourne

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 8

It is well known that Australia is the driest continent on earth. It is less commonly known that Australian streams typically exhibit large variations in flow with long periods of no flow being common in some regions. Development of the Nation's water resources has been rapid with the result that in the two hundred years since the first English settlers arrived, the prospect of full practicable development of surface water resources is close to becoming a reality in several areas. Increasing interest is now being shown in the potential of using reclaimed water to augment the available supplies.

This paper summarizes current re-use projects throughout Australia, including:

- o the Werribee Farm in Victoria, where Melbourne's wastewater has been used for pasture irrigation for beef and sheep raising since 1897;
- o re-use of water for irrigation of sports grounds in rural townships in Western Australia;
- o landscape watering in South Australia;
- o drip irrigation of vineyards used for wine grape production in South Australia.

Research and investigation work is also increasing. Particular attention is given to the work of the Victorian "Reclaimed Water Committee," which is responsible for development and coordination of research within the State of Victoria. Some of the major studies discussed include: investigation of the potential for re-use in Australia with particular reference to Victoria; vegetable growth trials; timber growth trials; health aspects related to re-use including virological studies and assessment of the potential problem of transmission of parasites; groundwater recharge investigations with diametrically opposed views being expressed by different States.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Wastewater Reuse - The CCMS Drinking Water Study

AUTHORS: Barry G. Tunnah, A. Shaikh, R. Richards

AFFILIATION: Gordian Associates

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 8

The problems of providing safe drinking water in highly industrialized nations are quite different from those usually encountered in less developed countries, where supply and microbiological quality seem to be the major concerns. However, new and potentially serious questions are raised by the proliferation of industrial chemical discharges into drinking water sources, urban runoff, water polluted by human waste (both treated and untreated), and by the formation of new chemicals in drinking water and from the interaction of disinfectant chemicals with the synthetic and natural substances commonly present in drinking water.

The primary objectives of the NATO Committee on the Challenges of Modern Society, (CCMS) Study on Drinking Water are therefore to achieve a better understanding of

(i) the drinking water problems shared by industrialized countries

(ii) solutions to these problems now available

(iii) potential problems for which solutions are currently not available, except perhaps at prohibitive cost.

The CCMS Study began in 1977 and is approaching completion. Six international working groups are studying various topics related to drinking water supplies, including analytical methods, advanced treatment technologies, microbiological factors, human health effects, groundwater protection and waste water reuse. This paper describes the status of the CCMS study with respect to water reuse, and presents some of the findings of the "state-of-the-art" review which has been performed by representatives of the seven participating nations (United States, France, United Kingdom, Netherlands, Sweden, Spain, Germany.)

The sub-topics which are covered by the CCMS study and described in this paper include the following:

1. Extent of current water reuse, including industrial and agricultural reuse.
2. Legislative background to the control of discharges into potential water sources.
3. Measurement of the degree of indirect water reuse (discharges into rivers used as potable water sources, etc.).
4. Treatment options.
5. Potential health problems.
6. Public acceptance factors.
7. Water resource management.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: An Assessment of Legal and Institutional Barriers to Planned Reuse of Water in the Colorado River Basin

AUTHORS: J. Gordon Milliken and Loretta C. Lohman

AFFILIATION: Denver Research Institute

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 9

This paper summarizes a research study of the policy aspects of planned water reuse in the 242,000 square mile area of the Colorado River Basin. The policy study, which was sponsored by the Office of Water Research and Technology, focuses on the system of control, planning and management of water resources in a semi-arid region that faces serious problems because of the inadequacy of its water resources.

From a policy viewpoint, achieving a greater degree of planned reuse requires either: (a) identifying and overcoming various legal, institutional, political and economic obstacles to reuse, or (b) adopting strategies to promote reuse, by reinforcing existing incentives and facilitating factors or by creating new incentives. The interstate compacts, statutes and case law of the seven Colorado River Basin states contain some serious barriers to planned reuse and also some incentives to reuse.

A major barrier to reuse is the property nature of water appropriation rights. Reuse frequently is impossible without causing injury to other water appropriators. A state-by-state analysis identifies circumstances in which reuse might conflict with the rights of other water users to a given quantity of water, or to water that has not been reasonably degraded in quality.

Institutional barriers to reuse, based in administrative policy and precedent or regulatory interpretation, also are discussed. These institutional factors include administrative interpretations of the legal limitations on water rights, particularly such aspects as "historic consumptive use," "beneficial use," and "waste."

Several other legal, institutional and regulatory factors can affect planned water reuse. These include water quality constraints (which encourage consumptive reuse but discourage nonconsumptive), state health department regulations, state and national environmental constraints, state laws or policies regulating coal slurry pipelines, and state land use and zoning regulations.

Societal and special interest group concerns and attitudes can serve either as barriers or facilitators to planned water reuse, depending on the type of reuse proposed and on the alternate water source. An analysis is provided of the usual attitudes of recognized interest groups toward various types of reuse projects.

A final category of barriers and incentives apply to the proposed water reuser. A major barrier is economic: most potential industrial reusers can still obtain fresh water from conventional sources more cheaply than they can obtain and treat used water, particularly water of low quality. In some applications, reuse is prohibited by technological or physical barriers in treatment or transportation which cannot be overcome without unreasonably high expenditures. Following the assessment and analysis of various types of barriers to reuse, the paper outlines various methods or strategies to overcome the barriers and gives conclusions on their relative feasibility.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Public Participation in the Adoption of Innovative Wastewater Reclamation Projects

AUTHORS: William H. Bruvold

AFFILIATION: University of California, Berkely

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 9

A number of studies have been performed which attempted to assess public attitudes toward the use of reclaimed water for various purposes. A problem with many of these studies is that they dealt with an issue that was not salient to the respondents: the issue of using reclaimed water involved some other place or some future time. The present study assesses public attitudes toward water reuse options that are salient to the respondents: the options involve their own community in a time frame as close as the next municipal bond referendum.

The study makes use of specific wastewater treatment and reuse options developed for all California cities by the recent Statewide basin planning effort. Options are described in detail to a sample of voters carefully chosen from the city being surveyed by probability sampling procedures. The type of treatment called for, its economic impact, its environmental impact, and its health impact are all described in detail to all respondents before they are asked which option if any, they would support in a bond issue vote, and then why or why not. The study presents a method by which the public may meaningfully participate in technical decisions. Options developed by the engineering and planning sector are presented for public review before seeking a formal public referendum. In this way the technical sector can be informed of public opinion before selecting one reclamation option for a bond issue vote. Such a procedure holds much promise as a technique for improving the successful adoption rate of innovative wastewater reclamation projects and it exhibits a technique for public participation in the planning process that could have applicability in many areas other than water and wastewater.

The present research involves the survey of 140 respondents from each of ten California cities. At present three surveys have been completed and analyzed. The results presented are tentative and trends now visible may change once all data have been collected by the end of the current calendar year. However, it is still interesting to note at this point that, when faced with actual options for their own community, voters tend to favor most a high degree of wastewater treatment coupled with a moderate degree of contact reuse such as a recreational impoundment or agricultural irrigation. A very high degree of treatment coupled with high contact reuse was next most favored by the respondents of the first three cities surveyed with minimal treatment and disposal receiving the least support. The complete presentation will describe all such findings in detail for all towns studied as well as make recommendations for public participation in the adoption of innovated technologies.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: A Water Utility's Considerations for Implementing a Wastewater Reuse/Dual Water System

AUTHORS: 1) William G. Richards; 2) Patrick R. Cairo, and 3) Arun K. Deb

AFFILIATION: 1 & 2) Philadelphia Water Department; 3) Weston Environmental Consultants

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 9

Any decision concerning implementation of a wastewater reuse dual system is dependent upon many factors, including economics. In Philadelphia, a prime consideration will be the eventual cost of the water treatment methodology that will be required for the removal of trace organics. Because of the uncertainty of the final regulations which are to be promulgated by EPA, the exact scheme of Granular Activated Carbon (GAC) or other treatment is still unknown. There are still considerable cost differences between the alternatives under consideration.

In addition the City is presently attempting to institute a strong cross-connection control program. Such a program would be a necessity before any dual distribution system could be considered and Philadelphia's program is not yet well established. The question as to whether the cross-connection program administrators would be favorable to a public reuse distribution system has not yet been answered, but the existence of a non-potable high pressure fire system in the center city area would seem to set a favorable precedent.

Other major factors would be the response of the public, industrial and governmental sectors of society as well as increased regulatory requirements once reuse has been implemented. Reuse has been demonstrated to be acceptable to the general public in water-short areas of the U. S. Its acceptability has yet to be demonstrated in other areas. A substantial public information program would be required, especially should the dual system involve potential human contact. The cost of this program would probably be borne by the water utility. In addition since dissolved solids would be present in greater quantities in the reuse system than they would in the potable system, it would be expected that corrosion and deposition problems would occur more frequently.

Finally there are presently very few regulations from governmental and regulatory agencies concerning reclaimed water, reflecting the still limited status of reuse. It could be expected that as reuse becomes more prominent regulations would become more prolific and probably more stringent. These regulations would almost certainly increase the utility's health-related responsibilities above those now usually required. It would be expected that extensive monitoring and inspection procedures would be a minimum requirement. Research or pilot studies might be necessary to demonstrate practicality and effectiveness. It might also be possible that until a good health and safety record were established, additional funds might have to be set aside as a cushion against liability and health damage suits.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: East Bay Dischargers Authority (EBDA) Reclamation/Reuse Survey

AUTHORS: Daniel F. Murphy and Garry Lee

AFFILIATION: EBDA, Lowry and Associates

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 9

In the east San Francisco Bay, approximately 200 square miles has just recently been subjected to possibly the most intensive survey of potential reclaimed water use ever performed for an existing developed community. The unique feature of this study is the exhaustive search for potential reuse locations and evaluation of viability.

Formed in 1974 by two cities and three sanitary districts for the purpose of joint effluent disposal, the East Bay Dischargers Authority (EBDA) recognized early that highly treated effluent from federally mandated secondary plants could have beneficial uses other than disposal. An extensive treatment, transmission, and outfall system is under construction and will be completed in 1981. The force main connecting four treatment plants is designed for reversible flow so that the reclaimed water can be distributed along a corridor of approximately 20 miles in length.

With assistance from a Clean Water Act grant, the survey started in January 1978. The ultimate goal was to implement a phased reclaimed water reuse plan for all viable locations. The study was divided into two phases: 1) identify and locate feasible reuse - Reuse Survey; and 2) prepare detailed Project Report evaluating alternatives and costs, with the ultimate goal of implementation.

From the beginning, it was recognized that a significant amount of screening would be necessary to narrow potential uses to a manageable practical list. The first evaluation was based on environmental health concerns, regulations for treatment and quality, cost of treatment, etc. on a general basis screening uses to four types: 1) Landscape Irrigation; 2) Agricultural Irrigation; 3) Industrial Reuse; and 4) Wildlife Enhancement or recreational.

Totally, over 1000 sites were identified. A sample group analysis indicated that a distribution system of this magnitude would be prohibitive in cost. Therefore, the list was screened to 350 users, which had reasonable volumes of potential use to warrant further investigation. More detailed information was then obtained on user interest in reclaimed water, volume of use-peak and average, water quality requirements, storage facilities, etc. A screening technique was then developed to categorize potential users by volume, location, and cost of service. Potential users exhibiting a favorable cost comparison to alternative water sources (a total of approximately 140) were carried to the next level of screening. At this point, preliminary systems were sized and cost estimates evaluated, again screening users which did not show favorable cost comparisons to alternative sources of water. Upon completion, a list of approximately 15 to 20 projects serving 25 to 30 users was concluded economically viable.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25—30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Institutional Barriers to Wastewater Reclamation and Reuse

AUTHORS: Richard L. Perrine

AFFILIATION: U.C.L.A.

DATE OF SESSION: Wednesday, March 25 *SESSION NO:* 9

This study addresses institutional barriers to enhanced reuse of wastewater as a supplement or replacement for added freshwater supply. The primary vehicle has been three case studies of reclamation activities in southern California. Facilities used as examples are the San Jose Creek, Pomona and Water Factory 21 reclamation plants. Four areas of critical institutional concern are analyzed: (1) issues related to the administrative and institutional framework within which operations must be managed, (2) the legal framework which applies to reuse, (3) the economics, financing and pricing of reclaimed wastewater, and (4) issues growing from the risk to public health of reuse of treated wastewater. Conclusions as to issues of major importance are presented and recommendations drawn which could enhance wastewater reuse potential. The most important issues relate to health risk and its proper assessment. Others relate to the efficient, integrated planning and management of all water supplies. Proper cost comparisons between alternatives, consideration of external costs, and financing also constitute an important issue area. Legal requirements and the level of government best suited to manage also are considered. General conclusions as to further research needs are presented.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Economics of Water Reuse in Metropolitan Water Supply and Wastewater Management
AUTHORS: Sashi K. Mozumder

AFFILIATION: U.C.L.A.

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 9

An economic framework is presented for integrating metropolitan water supply and wastewater management decision. Emphasis is on evaluation of water reuse as a "source," in addition to groundwater and local and imported surface water, when demands (for potable and non-potable water) are price sensitive. Principal decisions include 1) when and how much to invest in water and wastewater treatment facilities, local surface reservoirs, local groundwater pumping and recharge capacities, 2) dual sector water prices over time, and 3) amount of water imported over time. Decision variables are selected to maximize total willingness to pay (which is defined as the discounted sum of the areas under demand curves) minus total (capital, operation and maintenance) costs, subject to hydraulic, financial and residual emission constraints. The model is dynamic and considers a time horizon of twenty-four years (can be extended).

The model can be used to evaluate the impact of rising energy costs on water and wastewater treatment, transshipment and pumping, and water price. It can also be used to evaluate economic gains from permitting direct reuse of reclaimed water in the non-potable sector (vs. no direct reuse except by groundwater recharge). Finally, it will be useful in evaluating the sensitivity of investment decisions and water prices to variation in receiving water quality standards.

To illustrate these uses, this framework is applied to the Northern Santa Clara Valley Water District in the San Francisco Bay area. This agency wholesales water to a rapidly developing metropolitan region consisting of several communities. It imports water from two different sources in addition to its own surface and groundwater supplies. The options available for future water development to meet the growing demands of the region are: a) development of a new imported source, b) increase local reservoir yields and, c) reuse water directly from advanced wastewater treatment plants or indirectly by recharging it to the groundwater.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Reliability of Advanced Wastewater Treatment

AUTHORS: 1) Perry L. McCarty, 2) Martin Reinhard, and 3) David Argo

AFFILIATION: (1&2) Stanford University; (3) Orange County Water District

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 10

Water Factory 21 is a 0.66 m^3/s (15mgd) advanced wastewater treatment plant operated by the Orange County Water District, California, to improve the quality of biologically treated municipal wastewater so that it can be used to provide the injection water for a seawater barrier system. Processes included are lime treatment, ammonia stripping, breakpoint chlorination, filtration, activated-carbon adsorption, reverse osmosis, and final chlorination. Because of interest in the use of reclaimed water to augment the domestic water supply, a study was initiated about 2 1/2 years ago to evaluate the variation in effluent quality and the efficiency of treatment for inorganic, organic, and biologocal contaminants. This paper will present results of this long term study.

Organic contaminants have been monitored using the volatile organic analysis (VOA) which measures volatile materials such as the trihalomethanes; closed loop stripping analysis, which measures less volatile components such as chlorinated benzenes and aromatic hydrocarbons; and solvent extraction (SEA) which measures pesticides, PCB's and other chlorinated organics. Over 100 organic compounds have been identified in the influent to Water Factory 21. Of these the concentration of about 20 are sufficiently above the detective limit to permit statistical analysis of their distribution in the plant influent and effluent over a period of time, and to evaluate plant efficiency for their removal. In addition, these 20 are of toxicological significance.

A range of heavy metal contaminants and major inorganic ions are also monitored routinely, and their frequency distribution in the treatment plant influent and effluent will also be presented. Also to be included is a summary of results of analysis for animal virus.

Statistical analysis has indicated that the time distribution of trace contaminants can best be described by a lognormal distribution. Similar plots have been made for all trace contaminants. The results of this analysis will allow evaluation of the percentage of time for which a given constituent exceeds a given concentration. Using this information the reliability of Water Factory 21 for meeting given standards can be determined.

The reliability of Water Factory 21 is enhanced by its function as a producer of reclaimed water. There is no necessity to treat water if it happens to be of unusually poor quality or if Water Factory 21 is in need of repair. The plant can and is shut down for periods of time for routine maintenance or plant modification. This flexibility to stop operation at will is an important factor which increases the performance reliability of Water Factory 21. Factors affecting reliability will be discussed in this paper.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25—30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Human Factors in Design and Operation of Reuse Facilities

AUTHORS: Roy D. Miller and Walter P. Lambert

AFFILIATION: U.S.A.M.B.R.D.L.

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 10

Reuse and advanced waste treatment facilities should be developed and designed on the basis of parity between product quality and human factors. Difficulties already experienced in treatment plant operator skill level, continuing operator training, plant operations to design expectations, and plant maintenance will magnify when higher technology plants are brought on-stream in the near future. Implementation of advanced technology for discharge or recycle is starting to look more like a specialized process industry rather than a simple extension of traditional wastewater treatment. In like manner, personnel for operation and maintenance of such facilities should probably be trained and have skill levels similar to industry technicians rather than traditional sewage treatment plant operators. We suggest such a dramatic upgrading of personnel is unlikely over the next 15 - 20 years. Instead, we believe that existing staffs or new individuals with similar training and skill levels will be expected to operate and maintain advanced technology facilities. It is critical, therefore, that researchers, developers, and designers include careful consideration for human engineering aspects of reuse and advanced waste treatment facilities. Unit process selection, for example, should be made as much on the basis of operability and maintainability by current staff as on the basis of engineering performance. We propose that design and construction of facilities which cannot be operated by existing staff to design expectations represents a waste of time and money.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Pilot Plant Demonstration of an Automated, Transportable Water Processing System

AUTHORS: Myron K. Lee and L. H. Reuter

AFFILIATION: Life System, Inc., U.S.A.M.B.R.D.L.

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 10

Limited sources of natural fresh water, together with the possibility of ground water poisoning by the enemy, make the reclamation of wastewater for reuse extremely vital to the operation of the combat unit and the Army field hospital in water deficient areas. In response to this need, the U. S. Army Medical Research and Development Command has been developing a wastewater reuse system. The interim objective is reuse of nonsanitary wastewaters for nonpotable hospital requirements. The ultimate objective is reuse for potable and nonpotable requirements. A full-scale pilot plant of a water processing system, equipped with a data acquisition system, was designed and built by Life Systems, Inc. The Water Processing System treats nonsanitary wastewaters of the U. S. Army field hospitals either for nonpotable reuse or for surface discharge to the environment and purifies natural fresh and brackish waters for potable use. The projected variations of the contaminant concentrations in the hospital wastewaters are 50-1,000 mg/l total organic carbon and suspended solids, 300-6,000 mg/l chemical oxygen demand, 500-4,200 mg/l total solids and 5-900 JTU for turbidity.

The Water Processing System pilot plant consists of four units: (1) a water treatment unit, (2) a water purification unit, (3) an ultraviolet/ozone oxidation unit and (4) an automatic instrumentation unit. In addition, the pilot plant is equipped with a data acquisition system. This paper describes in brief the design, configuration and operation of the Water Processing System.

When both the Water Treatment Unit and the Water Purification Unit are operated in series, the Water Processing System produces nonpotable reuse water from the hospital wastewaters. The Ultraviolet/Ozone Oxidation Unit is a supplementary unit to be used with the Water Treatment Unit or the Water Purification Unit, while treating certain hospital wastewaters with high organic concentrations. The ultraviolet/ozone oxidation is used as a final purification step to destroy and eliminate residual organic contaminants in the process water. The Automatic Instrumentation Unit provides the control and monitor functions for the above three units.

The Water Processing System has a nominal product water capacity of 3,500 gallons per 20-hour day. The product water recovery is at least 85% of inflow in the production of reuse water and 90% in the production of potable water. The overall contaminant removal efficiencies are 98.9% for total organic carbon, 99.5% for chemical oxygen demand and 98.5% for total solids.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: The Reclamation of Domestic and Industrial Wastewaters

AUTHORS: L. R. J. vanVuuren and M. P. Taljard

AFFILIATION: National Institute for Water Research - Pretoria, Republic of South Africa; and Municipality of Capetown

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 10

During the past fifteen years the National Institute for Water Research has conducted extensive research on the renovation of effluents for reuse. These effluents were derived from various types of wastewater treatment facilities including conventional trickling filter plants, activated sludge systems with and without biological nutriant stripping and oxidation pond systems. Investigations also included the reclamation of raw and primary treated domestic wastewater and effluents of predominantly industrial origin.

More recently the research has been extended to the integration of wastewater treatment with advanced treatment technology.

A pilot plant (100 $k\ell.d^{-1}$) was constructed to reclaim raw domestic wastewaters using the following basic process stages:

Chemical pretreatment by high lime dosage or

ferric chloride addition as primary coagulant,

biological nitrification and denitrification,

filtration,

active carbon adsorption,

disinfection by breakpoint chlorination.

A second pilot plant was erected for the reclamation of secondary treated industrial sewage. The secondary treatment facilities comprising biofiltration were sensitive to toxic industrial wastes which resulted in a poor quality effluent for reclamation purposes. Chemical pretreatment of this secondary effluent followed by biological treatment produced a high degree of biological degradation and complete nitrification. The future program for this plant will be directed towards the reclamation of raw industrial sewage using the integrated chemical biological approach on the basis of experience gained with the plant.

The paper presents detailed process criteria, cost estimates and quality data relevant to the respective pilot plants. The main conclusion is that integration of sewage treatment and water reclamation should receive serious consideration when planning a water reclamation system.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: U.O.S.A. AWT and Indirect Reuse

AUTHORS: Millard H. Robbins, Jr.

AFFILIATION: Upper Occoquan Sewage Authority

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* 10

Under the auspices of the Upper Occoquan Sewage Authority, a 15 mgd AWT plant was constructed in Fairfax County, Virginia. The new facility took the place of several smaller inadequate plants discharging a poor quality effluent into the watershed. The AWT effluent will flow into the Occoquan Reservoir which serves as the rainwater source for 600,000 people in Northern Virginia.

In July, 1971, the State Water Control Board issued what was termed the "Occoquan Policy" mandating a regional collection system and "fail-safe" design in the treatment sequence. Not only must the facilities incorporate the best available technology but component redundancy was required. Initially, the policy required 100% backup for liquid processes dual electric transmission facilities plus emergency on-site power generation.

Stringent discharge limitations were imposed which include: BOD - 1 mg/l, COD - 10 mg/l, SS < 1 mg/l, P- 0.1 mg/l, turbidity 0.4 NTU, and fecal coliforms <2/100 mls. To meet the standards the following treatment sequence is employed:

1. Conventional primary/secondary
2. Chemical clarification and recarbonation
3. Mixed-media filtration
4. Carbon adsorption
5. Ammonia removal with clinoptilolite
6. Disinfection

Organic sludges will be composted indoors for agricultural use and ammonium sulfate will be recovered using the ARRP process.

Redundancy, however, is expensive and the sophisticated plant cost close to $82 million to construct with a $3 million annual O&M figure at 15 mgd. The cost per 1000 gallons approaches 57 cents.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: The Application of Non-Potable Water Systems to Residential Service

AUTHORS: H. Will Stokes and M. E. Ford, Jr.

AFFILIATION: Las Virgenes Municipal Water District, Boyle Engineering Corp.

DATE OF SESSION: Thursday, March *SESSION NO:* 11

In areas where limited opportunities exist for indirect or direct reuse of reclaimed wastewaters, non-potable water systems for the delivery of a quality reclaimed water for uses such as residential irrigation and toilet flushing should be considered.

Institutional, environmental and economic restraints to such a system for the Las Virgenes Municipal Water District in Los Angeles County, California are examined.

The District's basic reclaimed water system and pending additions are described. Because of the impact of suburban developments upon the District's water and sewerage systems, considerable interest has been shown by developers in a non-potable water system to supply residential landscape irrigation water within the tracts which they are planning. Since it is the policy of Las Virgenes Municipal Water District to encourage reclamation and reuse of wastewaters in its district, a program for a non-potable water system has been developed. The program consists of three main areas of emphasis:

1. A carefully controlled program of construction and identification of non-potable water facilities.
2. A means for cross-connection control.
3. A program of consumer education and monitoring of the use of non-potable water.

The expressed concerns of health authorities are outlined. The basic concern is that unintentional short-term ingestion of reclaimed water will be damaging to human life and/or health. The primary health hazards from non-potable, reclaimed waste water are toxicity, disease pathogens, and carcinogens.

Probabilities of accidental ingestion of a dangerous non-potable water supplied as a result of some process failure must be considered in assessing the hazards of a non-potable water system for residential use.

Las Virgenes Municipal Water District is located in the western end of Los Angeles County in a rapidly growing suburban atmosphere. The basic water supply for the District is high quality State Project water delivered by the Metropolitan Water District of Southern California. Even after one domestic use cycle, the water is still of relatively good quality for Southern California. Examples of the domestic water quality are given. There are relatively few industries within the District and the industrial waste water ordinances of the District closely control the substances which industry may contribute to the waste water system.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Impact of Pretreatment Regulations on Reuse Potential of Municipal Wastewaters

AUTHORS: Jon C. Dyer

AFFILIATION: Environmental Technology Consultants, Inc.

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 11

The general Pretreatment Regulations (40 CFR, 403) as mandated by the Clean Water Act (CWA) of 1977 (P.L. 95-217) will have an impact on the water reuse potential of municipal wastewaters.

Historically, industries have discharged process waste streams directly into municipal wastewater collection systems. These wastes have been treated in conjunction with municipal wastes and in many areas have caused several operational problems and plant upsets. Slugs of concentrated toxic pollutants wipe out biological activity for extended periods of time in treatment facilities. Toxic materials may bypass the treatment process discharging directly into the receiving stream. Heavy metals from some industrial processes are not predictably removable in very low concentrations, ending up in waste sludges and effluents.

The intent and goal of the pretreatment program (administered and enforced by the POTW) is to make municipal effluents and sludges acceptable for reuse.

Implementation of pretreatment programs will help to control POTW upsets and substantially reduce priority pollutants in municipal treatment plant effluents and waste sludges. POTW's will be able to meet more stringent discharge standards and potential reuse of municipal effluents will be enhanced.

EPA is developing national, technology-based categorical standards for indirect dischargers and POTW's will be required to establish local pretreatment programs by 1983 to enforce the appropriate categorical standards applicable to industries discharging into their system.

A case history will be selected to present data on the beneficial impact of pretreatment as related to municipal reuse.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Reclamation -- A Supplemental Water Source

AUTHORS: Garry E. Lee and William F. Hurst

AFFILIATION: Lowry and Associates, Irvine Ranch Water District

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 11

In Southern California, the Irvine Ranch Water District (IRWD) is implementing the concept of "Total Water Resource Management" for 80,000 acres by constructing a completely separate "Irrigation Water System." This dual system utilizes reclaimed water as the primary source supplemented by untreated imported water and groundwater.

In California, water quality and reuse is regulated by the State Water Resources Control Board and its nine Regional Water Quality Control Boards and the State Health Department. In October 1977 IRWD obtained a "producer/primary user" permit from the local Board and was the first such permit ever issued on this scale in the State. This allows IRWD to distribute reclaimed water to parks, schools, playgrounds, restricted recreational impoundments and all agricultural uses except for crops for human consumption with spray irrigation.

IRWD will ultimately produce approximately 38,000 acre feet per year of sewage. At the same time, demand for irrigation water (agricultural and common landscaping) is expected to range between 42,000 and 65,000 acre feet per year, depending on agricultural expansion. Common area landscape irrigation will require 30,000 acre feet per year. Therefore, nearly all of the sewage generated by development can be reused in common areas within that same development.

IRWD has recently obtained bond authorization for $995 million worth of future construction to implement total water resource management. Of this amount, $460 million has been set aside for the conventional potable water system, $334 million for the sewerage system, and $200 million for tertiary treatment and the irrigation system. Thus, IRWD will be implementing a first class dual water system.

At the present time, IRWD has made commitments only to a 15 MGD dual system using reclaimed water and is still evaluating the level to which they ultimately will irrigate as the disposal method. Consideration is still being given to ocean disposal as well as possible stream discharge. In past evaluations, a dual system has demonstrated its feasibility for IRWD by having lower total program costs. As plans are modified with time, the dual system concept will continue to be studied.

Although the extent to which each will supply the total irrigation needs and whether some disposal facility (such as an ocean outfall) is needed is yet undecided, IRWD has made a major commitment to the dual system.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Reclaimed Water Distribution System Planning - Walnut Valley, California

AUTHORS: 1) Roger C. Bales, 2) Edmund M. Biederman, and 3) Gary Arant

AFFILIATION: 1) Brown and Caldwell Engineers, 2&3) Walnut Valley Water District

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 11

Walnut Valley Water District, located in Los Angeles County, California, is currently planning to distribute reclaimed wastewater from the Pomona Water Reclamation Plant as an alternate source of supply in the greater Walnut Valley Area. This paper describes the year-long planning effort undertaken by the District to market this reclaimed water and to develop a feasible, implementable project that qualifies for federal and state Clean Water Grant funds.

Presently, there are approximately 235 miles of water mains that distribute water from the source of supply to customer meters. The proposed separate reclaimed water distribution system will involve about 20 miles of pipeline and will serve both medium-size users such as industries and golf courses and small landscape irrigation users at schools and parks. Four water agencies are involved in project implementation, whereas over eight local water agencies were involved in project planning. Institutional issues addressed during facilities planning included: (1) non-paralleling codes; (2) potential loss of revenue to public water companies regulated by the California Public Utilities Commission; (3) desire of agencies to maintain autonomy in water distribution projects; (4) regulatory agency constraints; and (5) varying water pricing policies.

The nearby City of Pomona currently sells effluent from the water reclamation plant for agricultural and some landscape irrigation in the vicinity of the plant, however, the Walnut Valley projects goes beyond existing levels of use. For that reason, a hard look was taken at the wastewater characteristics, plant reliability and requirements for reuse/discharge. In general, plant effluent is of better mineral quality than imported Colorado River water, and although it is recognized as an interruptible supply, plant reliability is acceptable for most potential uses with no direct potable supply backup at the customer meter. Because of both the need for over-sizing and a high degree of reliability, fire flows will continue to be supplied by the potable water system.

A preliminary pricing policy developed during the market assessment offerred potential reclaimed water customers a minimum savings of $40 per acre-feet off the highest usage rate now paid in their service area. These rates varied from a low of $131 to over $200 per acre-feet. The recommended pricing policy now indicates that the District will be in a position to offer a much greater savings, due to the availability of Clean Water Grant funds to partially cover construction costs. It is recognized that water reuse projects such as this do contribute to maintenance and enhancement of water quality in California and are consistent with the provisions of the Clean Water Act. In this post-Proposition 13 time, the local share of project costs will be financed by revenue bonds.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Wastewater Reuse - Resource Conservation

AUTHORS: William A. Duynslager

AFFILIATION: City of St. Petersburg, Florida

DATE OF SESSION: Thursday, March 28 *SESSION NO:* 11

This paper examines the St. Petersburg, Florida wastewater reuse program whereby treated wastewater is provided through a duel water supply system to the public for irrigation purposes. Treatment processes are described, including discussion of virus inactivation. Financial considerations are examined comparing the duel water supply system to other modes of wastewater disposal. Energy conservations are identified. A brief discussion of public relations programs is included.

The concepts contained in this paper can be applied to any community which has water supply shortages, long distances (costs) to import water, limited wastewater disposal options regarding receiving water quality criteria, and/or high energy costs.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: On-Line Automated Water Quality Monitoring

AUTHORS: 1) Kenji Nishioka, 2) William Roman, 3) Richard Brooks, 4) David Nibley, and 5) Richard Thomas

AFFILIATION: 1) NASA, 2) Santa Clara Valley Water District,(3, 4, & 5) Boeing Company

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 12

An on-line automated water quality monitoring system developed by the National Aeronautics and Space Administration's Ames Research Center and Lyndon B. Johnson Space Center has been tested jointly with the Santa Clara Valley Water District (SCVWD) at their experimental water reclamation facility in Palo Alto, California, from September 1977 through December 1978. The results of this demonstration test showed that on-line automated water quality monitoring is possible.

The water quality monitoring system is installed in a converted radar van and its operations can be partitioned into four main components: the sampling and sample conditioning component; the analytical water quality instruments and sensors; the data acquisition manipulation, display and storage operation; and overall system control. Basically the automation is achieved by placing the entire operation under computer control.

The sample flow is divided to flow past sensors and the operations of opening and closing valves, sensor control and data taking, etc., are computerized, resulting in real-time water quality measurements. Those sensors prone to drift are calibrated automatically by the computer on a pre-programmed basis between analyses. The output from the sensors is converted to conventional units and displayed on a cathode ray tube which is updated every minute. All data for the day is stored in active memory and hourly averages are stored permanently. Daily, weekly and monthly summaries for all sensors are generated from the stored hourly data.

A block of 21 sensors is used to measure 17 parameters including sample temperature, pH, halogenated hydrocarbons (including the trihalomethanes), total coliform, and total biomass. The sensors are a mix of commercially available sensors and custom sensors developed from the space program research.

Also, as part of this program, some basic research and development is being conducted to develop sensors and related technology, such as a viral sensor (laser detection), concentration of metallic ions and cations (for X-ray fluorescence detection), phenyl sensor (enzyme chemistry) and heavy metal sensor (enzyme chemistry). These activities are primarily being conducted at the universities but in all cases the development efforts are being made with the basic requirement that the finished instrument - sensor should ultimately be capable of being automated without undue difficulty.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Water Reuse Management Using Dual Supply

AUTHORS: Arun K. Deb

AFFILIATION: Weston Environmental Consultants

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 12

In October 1976, Weston began a two-year "Research Applied to National Needs" (RANN) Project for the National Science Foundation to investigate the feasibility of dual or multiple water systems. The objective was to develop an efficient and practical systems-analysis methodology to help cities, consulting engineers and other planners to analyze and decide whether the multiple-supply approach to water management will be beneficial in the long-term planning of water resources.

This paper discusses the use of dual water systems in urban water reuse management. A general systems model has been developed to simulate water reuse options, either for an industry, a city, or a region consisting of several cities. The model has been used to analyze the technical and economical feasibility of water reuse for long-term urban water management.

This paper also examines various reuse systems using dual water supply for technical and economic feasibility compared to conventional systems.

The computer model gives capital, yearly operation and maintenance and salvage value costs for a typical 25-year planning period for each unit operation or process. The costs for collection and transmission, treatment, residual handling and disposal and distribution are then converted to present worth and summed to give a total system cost for comparison.

In the future, the cost of production of potable water, particularly from polluted sources, will be very high; and with availability of good quality effluent, in many cases there will be economic incentive to reuse wastewater for nonpotable uses. Therefore, water reuse would be an essential consideration in developing a long-term water management plan for a city or a region. This systems model will help engineers and planners to evaluate technically and economically various water reuse options. Essentially the economic feasibility of a multi-supply water system over a conventional, single system depends on the savings from treatment costs over additional distribution cost.

Weston is presently testing the computer model in Tampa, Florida and West Philadelphia, Pennsylvania. This paper will discuss the results of the reuse analyses and present the potential application to other cities. The major cost components, rather than the hidden influences, will be emphasized. However, existing state regulations on dual water supply systems will be compared.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Systems Analyses Techniques Applied to Water Reuse Planning

AUTHORS: Myron S. Rosenberg and Harvey O. Banks

AFFILIATION: Camp, Dresser and McKee, Inc.

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 12

The true net economic benefits of wastewater reuse are situation-specific, inextricably linked to the overall water/wastewater system under consideration. Benefits vary, therefore, with factors such as temporal variation in water availability and demand, the nature and magnitude of various water users in the area of interest, and the quality requirements associated with various demands.

An analogy may be drawn with systems analysis and public expenditure theory currently being applied to river-basin planning endeavors. These tools appear amenable to analysis of water/wastewater systems. In planning for either system (river basins or wastewater reuse), one must tackle questions such as: What individual facilities should be components of the overall system? What is the optimal size, location, implementation schedule, and operating policy for each of these components?

To answer questions like these, river-basin planning and management techniques rely heavily on simulation and/or optimization models. Information generated by such models is then used in the decision-making (system planning) process. When applied to water/wastewater systems, these state-of-the-art techniques permit the costs and benefits (including internal costs and benefits) to be quantified. The approach provides additional information about the sensitivity of a proposed reuse system to assumptions made in the analysis. Moreover, systems techniques permit social objectives and preferences to be explicitly incorporated into system selection. Illustrative demonstration of the proposed approach is provided herein.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Design/Performance Analysis of Water Reclamation Facilities

AUTHORS: Raymond J. Avendt

AFFILIATION: Consoer, Townsend & Associates

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 12

The existing water reclamation facilities represent numerous process flow schemes that have been designed in accordance with the applicable State and Federal guidelines upgraded to reflect the design engineer's concept of optimization. This optimization primarily considers economics rather than a trade-off between design-dictated cost and performance. Numerous researchers have developed both emperical and systems analysis techniques for use in optimal process selection. The mathematical modeling techniques having the greatest benefit include linear programming, dynamic programming, geometric programming and network analysis. These techniques have been used to evaluate the cost-effectiveness of a treatment facility designed to achieve reuse water quality standards with a minimized cost.

This type of mathematical modeling has become very sophisticated recently and represents a method to validate the selection of a given reclamation plant design with the least cost. This cost-effective analysis, however, requires a major assumption to be valid. This assumption or simplification is that the treatment facility design performance equals the actual performance. Actual confirmation of this assumption has been limited due to the large number of unit processes available which operate at varying efficiencies. Many of the processes may be either compatible or synergistic depending on the operation conditions. If actual confirmation of process or flow scheme design performance could be realized, the design engineer and regulatory agencies would be able to weigh the performance in qualitative fashion. Performance would be considered not only as the ability to achieve a desired efficiency but as the reliability of the process or flow scheme. An immediate application of this type of performance analysis is the evaluation of reclamation plant design. The extremely high operational cost of these advanced unit processes is associated with treating specific types of wastewater constituents, i.e., nutrients and trace organics. If the performance level and reliability of the upstream treatment process, say, nitrification can be predicted, the subsequent costly denitrification may not be justified.

The purpose of this paper is to present the development of a modular software package for evaluating the design of a selected process or treatment scheme in relationship to performance and reliability. In order to achieve this end, a thorough evaluation of the various types of mathematical models used in water reclamation plant design and simulation will be presented. The individual process equations describing performance will be correlated to design criteria. The simulation models available will be reviewed to determine the extent of equations relating performance with design. The performance equations will be verified using an extensive data base of actual operating data and treatment process design criteria. The predictive capabilities of the model have been limited to the range of the data base.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25–30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Instrumentation for Automating Water Processing

AUTHORS: 1) Patrick Y. Yang, 2) J. D. Powell, Jr., 3) Walter P. Lambert

AFFILIATION: 1 & 2) Life Systems, Inc., 3) U.S.A.M.B.R.D.L.

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 12

A versatile computer-based instrumentation has been developed for real-time control and monitor of water processing systems. The automated water processing system of this development program was a full-scale pilot plant for a U. S. Army field hospital water reuse system. The water processing system was designed to treat nonsanitary wastewaters of certain field hospitals for nonconsumptive reuse or to purify natural fresh or brackish waters for potable use and at the same time treat the nonsanitary wastewaters for surface discharge. The pilot plan integrates the unit processes of equalization, prescreening, ultrafiltration, depth filtration, ion exchange, carbon adsorption, reverse osmosis, ultraviolet-activated ozone oxidation and hypochlorination.

The automatic instrumentation unit is designed to provide reliable operation, maximum performance, minimum operator skill level requirement, reduction of operator errors and simple operation of the complex reuse system.

The automatic control/monitor instrumentation unit uses state-of-the-art electronics to automate the water processing system, simplify the operational requirements, protect the system and personnel and handle the automatic data acquisition which was designed as part of this development effort. The instrumentation unit is characterized by:

- o Computerized, automatic process parameter control
- o Automatic operating mode control
- o Automatic operating mode transition control
- o Automatic setpoint modification
- o Fault detection and isolation analysis
- o System performance trend analysis
- o Interactive operator/system interface
- o Automatic data transmission to Data Acquisition System

The operator/system interface consists of a control panel, a system status summary display panel, an alphanumeric message display unit, an operator command keyboard and a recessed manual override panel. The message display and keyboard panel provides the operator with a convenient way of communicating with the system. Parametric data fault detection and trend analysis messages, operator error messages and control/monitor setpoints can be examined and displayed on the message panel. Control/monitor setpoints, scale factors, allowable ranges and control constants can be modified by an authorized operator easily from the front panel keyboard interface. The system operation including different operating modes, mode transitions and auxiliary maintenance modes are simplified with the automatic instrumentation unit.

The instrumentation unit can be used, with some modifications, to control and monitor other types of water processing or wastewater treatment systems.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25–30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Wastewater Reuse and Water Conservation at U. S. Army Installations

AUTHORS: 1) Stephen P. Shelton, 2) Curtis J. Schmidt, and 3) Ernest V. Clements
AFFILIATION: 1) University of South Carolina, 2&3) SCS Engineers

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 12

The Army has become interested in water reuse systems because many of its industrialized bases in the Southwest and Western United States are located in water-short regions. Since most of the existing full-scale water reuse programs in the United States are oriented toward irrigation, these facilities provided little background data for industrial reuse systems. For this reason the Army Medical Bioengineering Research and Development Laboratory initiated a research program to develop water reuse and conservation systems for application at Army installations. It was the purpose of this investigation to adapt, test, and apply a generalized computer-oriented water reuse and conservation model that would aid in selection of the most cost effective water use alternative at any Army installation.

To develop an effective water reuse and conservation model it is necessary to know the acceptable water quality for the various industrial processes, the degradation of water quality across the various industrial processes, and water usage for each process as a function of time. With these data a reuse and conservation model can be applied to provide adequate blending, storage, and treatment to fulfill the industrial system usage and quality requirements.

The adaptation of a generalized water reuse and conservation model was accomplished using a four-phase approach: (1) data acquisition, (2) model adaptation, (3) sensitivity analysis, and (4) application.

The water reuse and conservation model adapted during this investigation is a useful planning tool for comparative analysis of potential water reuse systems. The model provides a systematic methodology for organizing the basic information required to evaluate wastewater reuse and conservation potential and analyzing the tabulated data quickly to determine what potential reuse and conservation systems might be feasible. The model requires input and interaction with an engineer experienced in water and sewage management. Although computer oriented, the model is designed so that the engineer and the computer can be geographically separated and work effectively; i.e., hands-on interaction between engineer and computer is not required.

Important outputs of the model are the quantity and quality of supply water required by each activity, quantity and quality of wastewater generated by each activity, treatment required for reuse, storage requirements, results of blending of various wastewaters and/or freshwater pumping, pipeline transport, and estimated system costs.

Pollutant limits for supply water to various activities were found, however, to be virtually devoid of information. This is understandable because only isolated in-process industrial reuse systems are being utilized. As a result of this data shortage, it was necessary for the purposes of this investigation to estimate the acceptable water supply quality criteria for various activities.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Research and Demonstration Study of Food Crop Irrigation with Reclaimed Municipal Wastewater

AUTHORS: 1) Bahman Sheikh, 2) William R. Kirpatrick, and 3) Robert S. Jaques

AFFILIATION: 1&2) Engineering Science, 3) Monterey Peninsula Water Pollution Control Agency

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 13

A five-year research and demonstration program is now initiated in Monterey County, California to determine and demonstrate the feasibility of large-scale use of reclaimed municipal effluent for food crop irrigation. The food crops being studied are lettuce, artichoke, broccoli, celery and cauliflower. If the five-year project proves that food crops can be safely irrigated with reclaimed water, it will allow utilization of a projected 87,000 m^3/d, (23 mgd) from the north Monterey regional wastewater treatment plant (now under design) to be used for unrestricted irrigation of these crops.

The research and demonstration program has been planned in close co-ordination with many interested agencies in order to be responsive to concerns regarding public health, farm productivity and economy, public acceptance, virus survival and many peripheral issues. Design is nearly complete for a pilot wastewater reclamation facility that will deliver two separately treated AWT streams.

The study was preceded by an intensive site selection effort in which important criteria were: uniformity of the soil and its representativeness, willingness of the farmer/operator to cooperate with the study and proximity of the site to the existing secondary treatment plant. An agroclimatic station was established near the site to obtain preliminary data on wind, precipitation, temperature, etc. The randomized plots, replicated to provide for statistical analysis and computation of significance parameters, will be laid out in a pattern to normalize the effects of gradients in soil, wind and other consistent patterns which may exist.

The demonstration program's 1977-78 planning phase, included an environmental assessment of the proposed five-year project. Many issues emerged in public discussion, including farm workers' exposure to pathogens, aerosol transport to neighboring fields, cumulative effects on soils, economic impacts on the farm and consumer reaction. These issues were resolved through inclusion of adequate safety and monitoring activities in the long-term research program.

Samples collected from soils, plants and irrigation and tail waters will be analyzed for some 40 parameters, including viral, bacteriological, heavy metal (Cd, Zn, Hg, Pb, etc.) and other characteristics. Viruses will be assayed in water samples and on plant tissues, using methods which are now being developed in an environmental chamber study for this program at the University of California's Sanitary Engineering Research Laboratory in Richmond, California. These analyses are expected to provide the basic data for establishing documented long-term differences--if any--between using ordinary irrigation waters and the use of reclaimed water.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25—30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Reuse of Sewage Effluent in Urbanizing Irrigated Valleys

AUTHORS: Herman Bouwer

AFFILIATION: U.S.D.A. - Water Conservation Laboratory

DATE OF SESSION: Thursday, March 28 *SESSION NO:* 13

Water is a limiting factor for many irrigated areas. When such areas experience increasing urbanization, sewage effluent becomes an important water resource that can be used for irrigation, recreation, and industrial (cooling) purposes. Direct potable reuse is not yet recommended, because more research is needed on trace organics and other potential health hazards in the water. Ground water recharge with rapid-infiltration basins can be an effective method for improving wastewater quality so that it will meet agronomic as well as public health criteria for unrestricted irrigation. The resulting "renovated" water will also be suitable for lakes with primary-contact recreation. Movement of renovated water from rapid-infiltration systems into potable aquifers can be avoided and controlled by proper recovery of renovated water with wells or drains. If urban developments and sewage treatment plants are located around agricultural valleys, underlying aquifers can be used for renovation of wastewater and for transmitting it to the lower, agricultural portions of the valley. Pumping this water for irrigation then enables complete reuse of the wastewater. The paper will be illustrated with renovation and reuse projects in the Salt River Valley of southcentral Arizona.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25—30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Three California Water Reclamation Case Histories

AUTHORS: 1) Richard J. Stenquist, 2) Robert M. Hunter, 3) Robert L. Mills, and 4) Myron E. Steele

AFFILIATION: 1,2,3) Brown and Caldwell Engineers, 4) City of Santa Rosa, Ca.

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 13

Brown and Caldwell has had extensive experience in wastewater reclamation throughout its 30 years of providing engineering consulting services. This paper describes three recent projects.

Historically, the City of Santa Rosa has discharged secondary effluent to tributaries of the Russian River, a river with heavy recreational use. A prohibition of discharge during the summer months was imposed unless effluent received advanced waste treatment. Simultaneously, the local dairy industry was in need of low cost feed, and pressure was increasing to preserve open space. The city decided to maintain secondary treatment with summertime reclamation for agricultural irrigation and wintertime stream discharge. The 15-mgd Laguna plant was designed so that either activated sludge or advanced waste treatment consisting of nitrification-denitrification, phosphorus removal, and filtration could be provided in 5-mgd increments. This scheme is also designed into the 40-mgd ultimate plant expansion to provide flexibility for changing times. A fully operational summertime distribution system has been constructed consisting of pumping stations, pipelines and terminal reservoirs. Reclamation is accomplished both by contract with farmers and on city-owned lands.

The Milpitas-North San Jose Wastewater Reclamation Study found that over 50 potential users located within 5 miles of the San Jose/Santa Clara WPCP could be served cost-effectively. Potential wastewater uses include irrigation of agricultural crops, golf courses, parks and school grounds and industrial reuse primarily for cooling, washing and landscape irrigation.

Average demand of potential users is approximately 125,000 gpd and maximum demand is 630,000 gpd. With grant funding, the proposed facilities could produce and distribute reclaimed water at a cost of about $60 per acre-ft.

The Napa Sanitation District and its joint powers authority partner, American Canyon County Water District, are facing high operating costs for their 15-mgd physical-chemical algae removal facility which discharges effluent to the Napa River. Present flow is 7 mgd, which results in an annual budget of over $1.0 million. At the same time, nearby vineyard owners and other agriculturalists have been attempting for several years to obtain reclaimed wastewater for irrigation in their water-short area. Because oxidation pond effluent (which is the influent to the tertiary facility) is of sufficiently high quality for many reuse purposes, a reclamation program involving its use would benefit both the sewerage agencies (by reducing treatment costs) and the agriculturalists (by providing irrigation water at low cost.) A facilities plan on the reuse program is presently being completed. Approximately 50 to 75 percent (4,000 to 6,000 acre-ft per year) of the plant flow may be reclaimed by the Stage 1 project.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25—30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Ecologically Balanced Wastewater Renovation System

AUTHORS: Amit Basu

AFFILIATION: Engineers India, Ltd.

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 13

The wastewater renovation system proposed for Malanjkhand in Madhya Pradesh, India, is based on the findings of a Department of Science and Technology, Government of India, sponsored research project conducted by the author at Environmental Engineering Department, Jadavpur University, Calcutta. It is an ecologically balanced system which employs the natural recycling processes and helps maintaining the "Biogeochemical cycles." Conceptually, the system comprises a multiple celled stabilisation lagoon as the central waste water treatment unit surrounded by a green belt.

In order to establish the system's design parameters, studies were initiated towards (i) evaluating the agricultural use potential of community wastewater and its digested sludge; (ii) delineating the planning and management details of Pisciculture in treated wastewater; and (iii) determining the hydraulis and organic loading rates using treated effluent for different soil-vegetation complex. Crop growth as well as the extent of recycling of nutrients through harvested crops were studied. Quality of leachate reaching the ground water table was monitored by collecting the leashate samples by means of suction lysimeters. Physical, chemical and biological changes occurring in the soil mass due to application of treated wastewater were also studied.

Total volume of wastewater to be handled is 550 M^3/day, out of which 450 M^3/day is sanitary wastewater and 100 M^3/day is treated oily wastewater emanating from garage and repair shop.

Effluent coming out of the fish pond as well as the sludge deposited in the lagoon are applied on the land. There are two separated zones, one is earmarked for raising H. Napier grass with hydraulic loading rate of 50mm per week while the other for horticulture where flowering trees are raised. A recreational pond is also created using a part of the fish pond effluent where boating and angling are permitted.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Chlorinating Agricultural Reuse Water as a Method of Minimizing Plant Pathogen Contamination

AUTHORS: James R. Steadman, Rick W. Bay, Mark J. Hammer

AFFILIATION: University of Nebraska

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 13

An inevitable consequence of water reused after passing through crop production fields with diseased plants or infested soil is that water may contain and thus disseminate plant disease-producing organisms. Indeed, systematic sampling of irrigation runoff and reuse systems in Nebraska and other states demonstrated contamination of the water with plant pathogenic fungi, bacteria and nematodes. Inadvertent reuse of runoff water in the North Platte and Columbia Basin Irrigation Projects was a primary source of phytopathogenic fungal and nematode contamination in canals. Phytopathogenic bacteria also were found in Nebraska and Oregon canal systems and have resulted in crop losses. In designed reuse systems in Nebraska, nearly 60% of corn fields showing symptoms of Goss's bacterial wilt (Corynebacterium nebraskense) had runoff or reuse samples which were positive for the bacteria in a pathogenicity bioassay. In two instances detection of the organism in the runoff water preceded observation of disease symptoms in the field.

Selective assays for many phytopathogens are not available, and attempts to find a simply indicator for water-borne plant pathogens analogous to the coliform test were unsuccessful. An assay utilizing antibiotic resistant strains of phytopathogenic bacteria was developed. Pathogen strains resistant to nalidixic acid, streptomycin and/or rifampicin were enumerated selectively from water treatment experiments on nutrient agar amended with the antibiotics. This assay enabled chlorine studies to be conducted in natural irrigation reuse water.

A number of methods for minimizing plant pathogen contamination of reuse water are available, but chlorination may be the simplest and least expensive. The dearth of information on chlorinating agricultural water necessitated a determination of how water quality affects chlorination. Reuse water samples were assayed by standard procedures for temperature, pH, turbidity, total alkalinity, hardness, solids (suspended, volatile and total), ortho phosphate and nitrate. Ammonia plus organic nitrogen and pH had the most significant effect on chlorine disinfection. The pH levels of reuse water (6.3 to 8.6) covered a critical range affecting the disinfection efficiency of chlorine. Organic plus ammonia nitrogen was estimated by breakpoint chlorination at levels up to 10 mg/l, and interfered with chlorination by reacting rapidly with chlorine, forming chloramines of relatively weak disinfection capabilities. Phytopathogenic bacteria were similar to Escherichia coli in that low levels of free chlorine were adequate for disinfection. A free chlorine residual of 0.01 to 2.0 mg/l depending on pH and contact time or a combined chlorine residual of 5 to 10 mg/l provided 99 percent kill. Spores of fungal pathogens, however, required 10-15 ml/l free chlorine for 5 minutes at pH 6.5 for a 99% kill.

Pathogens located within host tissue are protected from chlorine. Thus, effective chlorination will depend on adapting other methods such as sedimentation or filtration to eliminate protected pathogens before chlorine treatment. Effective chlorination of reuse water may be obtained in the absence of protected pathogens by injecting directly into the return irrigation pipe.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Water Reclamation in California - 1978

AUTHORS: James Crook

AFFILIATION: California Department of Health Services

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 14

There are 212 wastewater reclamation plants in operation in California at this time. These provide reclaimed wastewater to a total of 350 use areas. The types of reuse at these use areas include: irrigation for pastures, fodder, fiber and seed crops, orchards and vineyards, and food crops; landscape irrigation for golf courses, cemetaries and freeways and landscape irrigation for schools, parks and playgrounds; landscape impoundments (both restricted and body contact), recreational impoundments; industrial reuses; ground water recharge, and the operation of estuarine wetlands. The total volume of reclaimed water exceeds 60 million gallons per year (185,000 acre feet per year.)

The Sanitary Engineering Section conducts periodic surveys of all wastewater reclamation facilities in the State. These surveys are designed to gather operating data, to evaluate performance of existing facilities, and to provide valuable information for the development of wastewater reclamation criteria and regulations. During the months of May and June 1978, the Section conducted a comprehensive survey of all the wastewater reclamation plants and use areas in California. The study included completion of a comprehensive questionnaire outlining the operating procedures and degree of treatment involved at each reclamation plant, data relative to the performance of the plant and the use area characteristics. By far, the majority of uses in California relate to agriculture.

Included in the wastewater reclamation regulations are regulations relative to treatment reliability and plant performance. During the 1978 study an analysis was made of the treatment reliability provisions available in the plants surveyed. Reclamation plants were analyzed in three general categories: 1-Standby power supply. 2-Adequate alarm system. 3-Adequate treatment reliability. Of the 212 plants, 85 are required to monitor reclaimed water bacteriological quality. Of the 85 plants, 54 or 63% had bacteriological violations cited in 1977. The types of uses requiring bacteriological monitoring include groundwater recharge, industrial reuse, restricted and non-restricted impoundments and landscape irrigation for golf courses, cemetaries, freeways, schools, parks, and playgrounds and food crop irrigation.

This performance data is generally in line with the data discovered during earlier treatment plant reliability surveys and has provided valuable data relative to the development of regulations. An increase in the types of uses for reclaimed wastewaterwater has been seen as the demand for wastewater reclamation increases and as a direct result of the drought that affected the Western United States during 1976-77. The State has a current goal of tripling the use of reclaimed wastewater by 1982. The information developed in this survey, and the application of the results hopefully will satisfy that goal and maintain the high public health standards applied to the use of reclaimed wastewater. The paper will also include a brief summary of existing wastewater reclamation regulations and criteria and a description of the regulatory process.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: The Detection of Human Cellular Toxicity of Organic Compounds in Wastewater

AUTHORS: Clive C. Solomons; Harold F. Walton

AFFILIATION: University of Colorado

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 14

Fractions of non-volatile organic compounds isolated by liquid chromatography on "Bondapak C 18" were tested for toxicity on human neutrophils, monocytes, and platelets. The adenylate metabolic system was chosen for study because of its importance in biological Stoichiometric coupling and metabolic energy transduction. High performance liquid chromatography on a microbondapak C_{18} proved to be a sensitive and rapid method for determining the intracellular adenine nucleotide pool at exposure levels of 0.1-1 ppm for standards of known chemical composition. Thin-layer-chromatography was used to detect the rates of metabolism of C^{14} labeled precursors of adenylate compounds. Significant reductions in the synthesis and pool size of adenosine triphosphate (ATP) were proportional to concentration in the 0-1 ppm range of added compounds. The in vitro toxicity effects of a variety of compounds such as chloroform, xylene, octane, hexane, trichloroethene, ortho and pera dichlorobenzene, etc. were ranked and found to be well correlated with the degree of human and rat toxicity reported in RTECS (Repository of Toxic Effects of Chemical Substances, NIOSH USPPH, 1976). Deleterious effects of concentrated fractions of sewage and water treatment effluent were easily detected especially in the less polar fractions. It was also possible to detect the effectiveness of carbon treatment in removing toxic materials from a concentrate of water obtained from the Los Angeles sanitation district. The efficiency of reverse osmosis as a method of detoxification was also determined. Although these techniques cannot detect every possible type of stress to the metabolism, significant effects have been observed on metabolic pathways in human cells which are recognized to be of prime importance in the control of the rates and directionality of chemical reactions in the living cell. These techniques appear to be suitable for the continuous on-line monitoring of effluents.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Health Effects of Groundwater Recharge

AUTHORS: Margaret H. Nellor, Franklin D. Dryden, Ching-lin Chen

AFFILIATION: Los Angeles County Sanitation Districts

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 14

In light of the desire to expand water reuse by groundwater recharge in Southern California coupled with concern over potential health effects associated with this reuse activity, the Los Angeles County Sanitation Districts have initiated a two-year study of the health aspects of groundwater recharge as Task 1 of the Orange and Los Angeles Counties Water Reuse Study. Four study areas within the Los Angeles/Orange County Region have been selected on the basis of historical or planned intentional reuse. These study areas include the Montebello Forebay and eastern section of the San Fernando Basin in Los Angeles County as well as the Anaheim Forebay and a coastal barrier injection site located in Orange County. Four interrelated areas of research have been identified to address the problems of health effects of water reuse via groundwater recharge as follows: 1) hydrogeologic studies which will attempt to determine the influence of reclaimed water on potable groundwater supplies, 2) intensive water quality characterizations of groundwater and recharge waters for minerals, nutrients, metals, gross organics, specific organics, viruses and bacteria, 3) toxicologic studies of groundwaters and recharge waters designed to isolate health significant compounds or classes of compounds and to assess the relative toxicity of these waters, and 4) an epidemiologic assessment of the health impact on populations in the Montebello Forebay who have been consuming groundwaters replenished in part by reclaimed water for a period of approximately 15 years. Data generated by the Health Effects Study will be used by regulatory authorities as a basis for making decisions regarding modification, expansion, or curtailment of existing recharge programs, and/or establishment of recharge criteria for new reuse projects.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Mutagenic Activity and Trace Organics in Concentrates from AWT Plant Effluents

AUTHORS: Herbert R. Pahren and Robert G. Melton

AFFILIATION: U.S.E.P.A. - H.E.R.L.

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 14

In order to determine if the renovation of wastewater for potable purposes could result in potential health effects for the consumer, effluents of several advanced wastewater treatment plants were concentrated by reverse osmosis, extracted with solvents, and the resultant extract subjected to testing for mutagenic activity and trace organics content. This paper will present the results obtained to date at the Lake Tahoe and Pomona facilities. Other AWT plant results and an overall evaluation will be published in a subsequent paper.

Some samples were positive for mutagenic activity while others were negative. All positives and selected negatives are being analyzed in detail for trace organics to determine if the mutagenic activity may be related to the quantity or structure of the constituents present. Results for specific organics and mutagenic activity, along with the treatment process will be discussed in light of potential reuse for potable purposes.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Biological Evaluation of Toxic Effects of Concentrated Organic Contaminants in Wastewater Processed for Reuse

AUTHORS: Nachman Gruener

AFFILIATION: Tulane University

DATE OF SESSION: Thursday, March 29 *SESSION NO:* 14

This report represents the results of a comprehensive series of toxicological studies designed to evaluate the health effects of the application of recycled water for drinking purposes. Water was prepared in a highly advanced domestic sewerage pilot plant. Some 400,000 liters of the finished water were concentrated down to a volume of 200 liters with a total organic carbon content of 700 mg/liter. This concentrate was incorporated into a gel-type diet which was fed to mice. A total of 900 animals was included in the experimental program, which extended to 150 days. The mice were tested for growth, food intake, mutagenicity, mortality, blood physiology and biochemistry, and liver and nervous system functions. Ten tissues were screened for pathological effects. Only marginal changes were demonstrated in these tests.

In a second series of experiments, rodent and human cells were tested *in vitro* for general toxicity, mutagenicity, and carcinogenicity. Results for all three effects in the tissue cultures were positive. These effects were significantly increased by the presence of a liver activation system.

These results show that exposure for a limited time (20 percent of a lifespan) to the concentrated, recycled water (about 100-1000 times present human exposure) does not lead to physiological changes in mice. On the other hand, the positive results from the mutagenicity and carcinogenicity studies in tissue culture indicated a need for more studies in this area.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25—30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Reuse of Municipal Wastewater as Makeup to Circulating Cooling Systems

AUTHORS: David J. Goldstein, Irvine Wei and R. Edwin Hicks

AFFILIATION: Water Purification Associates

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

Reuse of municipal wastewater for industrial cooling in the United States amounted to 154 million gallons in 1971. Although 80 percent of this volume was used for once-through cooling, there are currently many successful cases of recirculation type systems (cooling towers) operating satisfactorily on sewage plant effluent. Details of such systems have been collected from several countries and there is no doubt that this is a thoroughly practical reuse option.

Makeup waters successfully used fall in the range of 10-30 mg/l BOD, 30-50 mg/l o-PO$_4$, 1000-1500 mg/l TDS and 30-70 mg/l NH$_3$. The major problems are phosphate scale and biological fouling. Usual treatments are lime clarification and chlorination.

Most of the industrial users are power plants, who use high alloy metals to avoid corrosion, but industries using carbon-steel heat exchangers have not found much corrosion.

Several systems are run in such a way that biological oxidation and nitrification occurs in the tower giving improved characteristics to the blowdown.

A detailed design study has been made based on an average municipal wastewater composition in the Western United States. The object has been to show designers how to approach the problem of installing appropriate treatment and to show operators how to obtain the highest cycles of concentration while keeping the cooling system operating without problems. Two design approaches have been considered. The first is additional treatment of sewage plant effluent. This mostly involves lime addition to a high pH to remove phosphate followed by reduction of pH and the addition of soda ash to remove calcium. The interference by ammonia has to be considered and the treatment can be placed in the makeup stream or in a side stream. The second approach considered is to alter the municipal waste treatment plant by such procedures as (i) the addition of powdered activated carbon, (ii) the use of an anaerobic section ahead of the aerobic section for biological removal of ammonia and phosphate. Results, designs and recommendations are given.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Groundwater Recharge with Wastewater - Heavy Metal Movement

AUTHORS: Thomas E. Higgins and Glenn Compton

AFFILIATION: Arizona State University

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

Wastewater reuse is imperative in the United States. Potential uses of reclaimed wastewater are for irrigation and for augmentation of water supplies by groundwater recharge. Reuse of water, however, results in an increase in the concentration of heavy metals, a potential problem.

A survey was undertaken of heavy metal concentrations in Arizona wastewaters, wastewater sludges, and treated effluents. Existing data, taken by water and wastewater agencies, was analyzed and a sampling survey made to supplement and to verify existing data.

Laboratory studies were used to simulate groundwater recharge with wastewater containing heavy metals, and to quantify the effects of chemical precipitation and sorption reactions on the movement of metals in soil.

A computer model was developed to predict long term effects of the use of wastewaters containing heavy metals for irrigation and groundwater recharge. (This quantitative model was developed to predict the effects of groundwater recharge on heavy metal concentrations and to predict the effects of groundwater recharge on heavy metal concentrations in the soil of a percolation field and carryover to the groundwater). It would be useful in setting standards for concentrations of heavy metals in wastewaters used for irrigation or groundwater recharge. The model considers the effects of chemical precipitation, adsorption, and dispersion.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Rapid Detection of Coliform Bacteria

AUTHORS: Anthony M. Cundell, E. Findl, A. Pisani, and J. E. Porter

AFFILIATION: Bio Research, Inc.

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

A rapid coliform detection procedure based on the hydrolysis of a fluorogenic substrate by coliform bacteria is under development at BioResearch, Inc. The procedure involves the induction of the enzyme B-D-galactosidase in E. coli with Isopropyl thio B-D-galactopyranoside (IPIG). A cell suspension of the enzyme induced organisms is dispersed onto a layer of silicone oil on a modified microscope slide with an aerosol sprayer. Within the resultant microdroplets the fluorescent substrate Fluorescein di (B-D-galactopyranoside) (FDG) is hydrolysed by the coliform bacteria. Fluorescein is concentrated within individual oil-encapsulated droplets containing coliform bacteria enabling them to be counted with a fluorescence microscope. Good correlations between the percentage of fluorescent droplets in randomly selected fields of view and the cell density in E. coli suspensions and raw sewage have been established in the range of 10^5 to 10^8 coliforms per ml. Lower coliform densities may be determined after concentration by centrifugation. The applicability of the rapid coliform detection procedure to monitoring water quality of renovated wastewater is discussed.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25–30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Closed Loop Recycle and Reuse of Water Closet Flush Water

AUTHORS: Clinton E. Parker and John W. Reynolds

AFFILIATION: University of Virginia, Virginia Highway and Transportation Research Council

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

Results from both the research and development and field demonstration of a recycle-reuse concept for water closet flush water is presented. Data and analyses cover the period from the initial inception of the concept in 1970 through the completion of the field evaluation in July 1978.

Over a five-year period, bench-scale biological-physical treatment trains were evaluated to determine the suitability of this technology in the closed-loop treatment of water closet wastewater where the flush water is continuously recycled and reused an average of 20 times. Results from the laboratory operation of a completely mixed suspended biological growth unit followed by sand filtration indicated that biological oxidation would not be impaired and flush water reuse at the 95% recycle level would be clear, odor free, and acceptable to the user. Based on laboratory results a full-scale prototype was installed to demonstrate field reliability of the concept, to further delineate design criteria, and to test public acceptance.

Field evaluation of a flush system designed to handle an average flow of 37.8 m^3/d of flush water was carried out between November 15, 1976, and July 31, 1978. During this period over 7000 m^3 of flush water was treated by extended aeration and pressure sand filtration using a recycle ratio of 20. Water inputs into the recycle system resulted from potable water use wastage plus liquid human wastes. The wasted potable water came from wash basins, water fountains, and custodial services. The potable water input amounted to 5% of the total water used and resulted in a water balance at 95% recycle and reuse.

Recycled flush water met all criteria established for a flush fluid and was accepted by the user. A blue food coloring was used to remind the user that the flush water was recycled. No special water closet cleaning was necessary as a result of either the recycled water or coloring agent.

Results from this research conclusively demonstrated on a full-scale basis the acceptability of using biological oxidation and sand filtration as a treatment train for the reuse of water closet wastewater with a recycle ratio of 20. Closed loop reuse at the 95% level was shown to be more economical than a mineral oil system and offers a viable water saving alternative. The results provide the fundamental details necessary for the design and operation of a flush water recycle-reuse system.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25–30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Feasibility of Treating Hospital Wastewater by Lime and Pressure Ozonation

AUTHORS: 1) Archibald G. Hill, 2) John B. Howell, and 3) J. J. McCarthy

AFFILIATION: 1&2) Louisiana State University, 3) U. S. Army E.H.A.

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

Due to the nature of their mission, Army Field Hospitals require greater per capita water resources than similarly manned combat units. With the introduction of modernized equipment a trend toward increased water usage may be anticipated. The capability to renovate non-sanitary wastewater to a quality suitable for sub-potable uses could enhance the deployability of hospital units in arid environments.

The following list identifies sources of wastewater expected to be available for treatment.

Effluent Source	Approximate TOC (mg/l)
Shower	34
Operating Room	225
Kitchen	1120
Laboratory	246
X-Ray	800
Colorfast Laundry	605
Woolens Laundry	236

The Army has set a tentative reuse goal for trace organics at 5 mg/l TOC or 10 mg/l COD. A study by Abcor Incorporated evaluated the sequence of unit operations including ultrafiltration, reverse osmosis, and ultraviolet light activated ozonation. When treated individually, all hospital waste streams, except for the laboratory and X-Ray effluents, met the organics limitation after the reverse osmosis step. Bench scale studies had shown that laboratory and X-ray reverse osmosis permeates could be effectively oxidized by ozone aided by ultraviolet light. However, due to equipment and design problems, this was not demonstrated during the pilot scale tests. These workers recommended further pilot scale evaluation of ozone contacting.

The objective of the present investigation was to evaluate ozone contacting at elevated pressure. Final COD concentrations less than 10 mg/l were successfully achieved when $Ca(OH)_2$ doses from 196 to 423 mg/l were added to the reaction mixture. Inorganic carbon formed during the oxidation served to lower the solution pH. Precipitation of $CaCO_3$ prevented an undesirable buildup of inorganic carbon which could have scavengered OH radicals formed during O_3 decomposition.

Operation at elevated pressure may still be advantageous for this system when considering oxygen recycle. The minimization of volatile organics in the recycle gas may be required when using the electrical discharge method of ozone formation.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25–30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Assessment of Mutagenic/Carcinogenic Potential of Mixtures of Chemical Substances in Renovated Wastewaters

AUTHORS: Jitendra Saxena, D. J. Schwartz and M. W. Neal

AFFILIATION: Syracuse Research Corporation

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

The advanced wastewater treatment process employed at the Piscataway, MD plant was studied for its ability to remove or introduce mutagenic/carcinogenic substances, and to determine the distribution of the detected activity among various classes of chemical compounds. The physical-chemical treatment process used at the plant consisted of lime addition, recarbonation, duel media filtration, breakpoint chlorination and activated carbon adsorption. The study utilized the specially constructed strains of Salmonella typhimurium and Saccharomyces cerevisiae to assess mutagenic activity, and the mammalian cells - BHK 21 Cl 13 - to determine transforming activity.

The unconcentrated influent for AWT (secondary effluent from conventional treatment process) showed significant mutagenesis in the base pair substitution mutant TA 100 and 1535 of S. typhimurium. Mutagenic activity of the wastewater was increased after the recarbonation step (Mid point sample) suggesting that either recarbonation or the preceeding liming process promoted syntheses of mutagens. Partial removal/detoxification of mutagens was noted during breakpoint chlorination and/or activated carbon adsorption. Overall the mutagen concentration in the final effluent was no less than that present in the influent wastewaters.

In order to recover the wide variety of mutagenic/carcinogenic contaminants suspected to be present in wastewaters, three independent concentration methods were utilized. These included polyurethane foam columns, macroreticular resin (XAD8 + XAD4) and solvent extraction employing 15% methylene chloride in hexane.

The chemical mixtures recovered from influent, mid-point and effluent samples using the above concentration methods showed weak to moderate mutagenic activity in Salmonella and Saccharomyces at concentrate volume representing 50-100 ml wastewater. The presence of non-mutagenic toxic substances in the crude mixtures prevented utilization of the larger concentrate volumes in the assay. Mutagenic activity was highest in the mid-point sample, the secondary effluent being the second highest and the final AWT effluent being the lowest.

The solubility separation of the crude mixtures into chemical classes and measurement of the biological activity was performed in order to identify the active fraction. Such a study of AWT influent showed that the activity predominantly resided in the basic, strong acid and neutral fraction. The combined activity of all the fractions was greater than that of the crude concentrate. The mixtures recovered from the mid-point wastewater samples and final AWT effluent are currently being subjected to the analysis.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25-30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Observed Water Reuse and Bath Conservation Techniques

AUTHORS: Jeffrey M. Wehner and Robert M. Lewis

AFFILIATION: Hamilton Standard

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

As industrial waste water discharge standards become increasingly stringent, water reuse becomes increasingly important. In many industries, process water can be treated to a cleanliness to allow reuse in the production process. This reuse allows many plants to meet both current and future waste water discharge standards while also providing the potential for operational cost savings due to the reduced need for make-up water. In addition to these possible water cost savings, an industry such as electroplating and metal finishing can also realize further cost savings by reclaiming costly process solutions while also reusing the process water. In many instances, these savings in solution costs pay for the water reuse equipment in a short period of time.

As a contractor to the Effluent Guidelines Division of the U. S. EPA for more than four years, we have been involved with industry data collection surveys and plant sampling visits in both the Machinery and Mechanical Products and Electroplating industries. These data collection and plant sampling tasks have involved detailed study of the production process, wastewater treatment process, and effluent discharge level interrelationships at a time when water reuse is being employed at an increasing number of plants. This paper will present several detailed discussions of the water reuse practices that we have encountered at various plants in several industries.

Specific cases of process water reuse which minimize waste water discharge will be reviewed for plants involved with coil coating, porcelain enameling, copper and copper alloy products, battery manufacture, and electroplating. These examples will describe process water reuse prior to any treatment, water reuse after in-process and end-of-pipe treatment, and water being used from other processes. Some of these water reuse technologies are transferable from industry to industry.

In addition to process water reuse, costly solution recovery is also accomplished in the electroplating and metal finishing industry. Solution recovery of both common and precious metals will be discussed. Some of the specific examples of technologies utilized for both process water reuse and solution recovery will be evaporation, ion exchange, and electrolytic recovery.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: The Costs For Spray Irrigation Land Disposal of Municipal Wastewater in California

AUTHORS: Dale R. Hurd, William W. Wood, Jr., Victor B. Youngner & Gary J. Benoit

AFFILIATION: University of California - Riverside

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

Twenty-one new (post 1970) community sewage treatment systems provide the data base for this cost analysis of spray irrigation land disposal for secondarily treated wastewater in California. Data for both fixed and variable costs are analyzed by multiple regression and factor analysis in an attempt to determine the relationship between these costs and the underlying influencing factors. Special attention is given to the investigation of the relationship between treatment facility type (i.e., extended aeration vs. contact aeration) and energy costs.

Two recent developments lend especial revelance to the results of this project. First, the EPA's mandate that new wastewater treatment systems must investigate the cost effectiveness land disposal of treated wastewater. Second, the findings of studies conducted in New England which indicate that the failure of engineers to anticipate the great energy-cost escalation and to design energy-conserving wastewater systems has increased operating costs to municipalities by 40% to 90%.

The results will be presented and discussed within a framework of unit cost functions relative to capacity (million gallons per day, and population equivalency), topography, and treatment plant type. Fixed costs are broken down into land, treatment plant, interceptor lines, irrigation distribution system, pumping stations, monitoring systems, installation, and heavy equipment. Variable costs are composed of labor, power, treatment chemicals, sludge disposal, and repair. Fundamental characteristics of plant types are defined and shown to influence the basic parameters which demarcate the setting in which costs are incurred.

This paper is intended as an application of research which will provide insight into many pressing contemporary policy questions as well as provide feedback to design engineers on the operational vagaries of recently constructed systems. Also, this paper is intended to be part of a broader area of research directed toward the question: How can funds best be allocated to minimize the societal costs of wastewater treatment?

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Post-Treatment of Secondary Effluent for Drip Irrigation

AUTHORS: Reginald H. F. Young, L. Stephen Lau, I-pai Wu, Harris M. Gitlin

AFFILIATION: University of Hawaii

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

Field Research by the University of Hawaii, Oahu Sugar Co., and the Hawaii Sugar Planters' Assn. together with the City & County of Honolulu Dept. of Public Works and Board of Water Supply has demonstrated that domestic wastewater activated sludge effluent can be applied as a supplemental irrigation water for sugarcane without detriment to sugar yield. The sugar industry in Hawaii is rapidly increasing its use of drip irrigation, thus the appropriate management of the effluent as a water resource requires the investigation and resolution of treatment needs and potential plugging of the drip tubes in effluent applications.

There is a problem at present in existing drip irrigation systems because of plugging o the drip tube orifice due to suspended material, including microorganisms, in the water supply, a problem that exists with even the highest quality water. Current plantation practice is to provide pretreatment by sedimentation and/or screening followed by pressure sand filtration using coarse-grained (#11 mesh size) material at high filtration rates (20>gpm/sf) with intermittent chlorination to oxidize slime growth in the drip tubes.

A pilot tube farm has been installed at the Mililani wastewater treatment plant to stud the necessary treatments of activated sludge effluent for drip irrigation. Four types of effluent will be processed through post-secondary treatment: 100% secondary effluent, and the 50% - 50% mixture after 3 days detention in a deep holding tank to simulate detention in a field storage reservoir. Efficacy of treatment and drip irrigation will be determined by post-treatment water quality and rate of plugging of drip irrigation tubes. The study will require 18 to 24 months to complete full testing of the various schemes.

Mililani treatment plant activated sludge effluent and Waiahole Ditch water quality data have been acquired since November 1977. Mean values were: suspended solids 31 and 23 mg/l, total plate count 3 and 30 organisms x 10^3/ml, total coliform 34 and 970 organisms/ml, and total organic carbon 56 and 17 mg/l for the effluent and ditch irrigation water respectively. The volatile suspended solids content was 90% for the effluent but only 30% for the ditch water, indicative of the higher organic content in the effluent solids.

The post-treatment and tube farm installation is undergoing first test runs at the present time. The post-treatment system consists of two-stage pressure filtration after passage through a 60-mesh screen, coarse filtration through No. 4 anthracite coal followed by fine filtration through No. 11 quartz sand. Filtration rate is 20 gpm/sf. The filtrate is given chemical treatment by chlorination, bromine chloride, or chlorine dioxide at a dosage equivalent to a 10 mg/l chlorine residual at the end of the drip tube line. The system and chemical dosages will be varied subsequently to a level that will yeild the least plugging. A check or control with no chemical treatment is included. The rows of tubes are visually surveyed and flow fountains from each orifice counted as flowing, half-plugged or plugged. The tube farm is automated and is operated on a 24-hour day schedule, processing 100% effluent for 12-hours and 50% - 50% dilution for 12-hours. Backwash takes place at the end of the run.

Tube farm operating data are being accumulated and will be presented in the final paper.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Integrated Use of Bioassays and Chemical Analyses to Evaluate the Quality of Reuse Water

AUTHORS: Terence E. Cody, Victor J. Elia, C. S. Clark and R. T. Christian

AFFILIATION: University of Cincinnati, Kettering Laboratory

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

The design and operation of water reuse systems must be carefully monitored to insure that the quality of the water produced meets standards for the intended uses. A monitoring approach involving biological assay and chemical separation and analysis techniques had been used to evaluate the design of a direct water reuse system. Addition of bioassays to the chemical and physical methods improved confidence in the quality of the product water because of the presence of an indicator of biological effect. The biological assay employed in our experiments was one using mammalian fibroblasts in culture.

By coupling toxicity analysis with chemical analysis and engineering design criteria, it is possible to identify and take steps to eliminate or reduce toxic components in product waters. Changes in product water due to alterations in the design of the reuse system can be easily measured in terms of improvement or deterioration of its biological and chemical properties. The approach has also been used to determine which step in the process is the most effective one for removal of specific toxic components. The optimum conditions required for removal of the toxic substance can also be determined using the bioassay.

The water sample to be tested was incorporated into the fibroblast culture growth medium. When undiluted samples were tested, the sample itself made up ninety-eight percent of the aqueous part of the culture medium. The bioassay conditions can be adjusted to suit test samples containing suspended particles or high concentrations of dissolved materials. Extremes of pH must be adjusted toward neutrality. Bioassay techniques using cultured cells can be used to measure general toxicity or mutagenesis/carcinogenesis. Several water samples or dilutions may be assayed simultaneously for the presence of toxic components in approximately five working days at moderate cost. Assays for the presence of mutagens using this technique requires about three weeks. The bioassays are very susceptible to low levels of toxic or mutagenic materials in the water samples and the intensity of response is dependent on concentration of toxin present.

In our studies, wastewater was treated in a laboratory-scale direct reuse plant comprised of a centrifuge, reverse osmosis module, and ozone contact chamber. Chemical composition, temperature, and pH of the wastewater; flow rate of the wastewater; and concentration of O_3 were controlled variables. Two simulated wastewaters were used in the studies, one was a chemically-defined mixture and the other was prepared from commercial products and chemicals mixed to approximate the wastewater from a small hospital. The physical, chemical and toxicity properties of the waters produced by the reuse system from these wastes was evaluated. The plant was operated under different conditions and the outputs were compared on the basis of degree of toxicity and/or adverse chemical attributes. In addition to standard physical chemical analyses, gas chromatography and high pressure liquid chromatopgraphy were used for major organic component separations. Even though all components are not specifically identified, differences in the "fingerprint" chromatograms of the water samples before and after treatment are very helpful in making design decisions.

Methods and applications of bioassay - chemical separation techniques will be presented and will be presented and will be illustrated with examples from our research.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Water Management Plan for a Midwestern Utility

AUTHORS: Chiranjit Chakraverty

AFFILIATION: Envirosphere Company

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

The water management plant for a two unit 1200 MW plant for a midwestern utility is discussed. The plant is located on the Ohio River and is currently under construction. It i classified as an existing source and is required to meet the "Best Available Technology Economically Achievable" level of effluent standards. The water management plan for the plant minimizes water intake and final discharge by maximizing reuse of waste streams to the extent possible within the constraints of efficient operation.

The plant is being designed for cyclic operation. This required special consideration fo handling the cooling tower blowdown. The blowdown temperature is expected to change considerably during the 24-hour period. This could have an adverse impact on the aquatic ecosystem due to thermal shock. It was therefore decided that the blowdown be routed thro the ash ponds prior to discharge into the river. This ensured a discharge that would exhibit a minimal variation in temperature. In addition, this would eliminate any possibl problems with residual chlorine concentrations in the blowdown.

The influent sources of water are deep wells, the Ohio River, and rain water. Surface water will supply all circulating water makeup and fire protection water. Ground water usage will be limited to demineralizer feed, potable and sanitary needs, and other miscellaneous uses. The water management plan incorporates a cleaning waste retention basis, a collection basin, the bottom ash pond, and the fly ash pond. All wastewater streams in the plant are directed to one of these basins or ponds. Treatment for the removal of specific pollutants from a waste stream will be provided, as necessary, before the waste stream mixes with other wastes. Wastewater from the cleaning waste retention basin will be discharged to the collection basin after treatment. Water collected in the collection basin will be directed to the bottom ash pond which overflows into the fly ash pond. The bottom ash pond is utilized as a source of water reuse within the plant. Overflow from the fly ash pond if the final effluent from the plant. Due to the long retention time provided in the ponds, the chemical and physical characteristics of the final effluent are not expected to fluctuate significantly from day to day. The pH of the fly ash pond effluent cannot be predicted at this time. A study has therefore been recommended to determine the need for neutralization of the fly ash pond effluent. A neutralization facility will be constructed, if necessary, to treat the fly ash pond effluent prior to its discharge into the river.

The water management plan presented was discussed with both state and federal regulatory agencies during its preparation. The plant effluent will meet all current regulations. In addition, the system is capable of being retrofitted to meet any future regulations including total recycle and zero discharge.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Irrigating Private Land with Wastewater Effluent

AUTHORS: James D. Earles and Larry C. Amans

AFFILIATION: CH_2M Hill Engineers

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

Secondary treated effluent is being used to irrigate private pastureland in Tuolumne County, California. During the summer of 1978, effluent flows of about 1 mgd, collected from a regional wastewater system, were distributed to 15 individual ranchers for application to 150 acres of irrigated pastures. Ultimately, 33 ranchers with a combined 1,100 acres will be receiving the design effluent flow of 4 mgd.

In 1972 the disposal in inadequately treated sewage effluent to the local surface waters in Tuolumne County area was prohibited by order of the California State Water Quality Control Board. Various alternatives for disposal of the effluent were considered including irrigation reuse on district-purchased land or private ranches and surface discharge of upgraded effluent. A system of discharging to individual pastureland parcels was found to be the most cost-effective solution. However, initial efforts to sell the idea of wastewater reuse met with stiff local opposition. After a year of meetings with small groups of opponents to the plant, the District and its consultant, CH_2M HILL, were able to gain the support of the community. Final design of the system was completed in the fall of 1977 with construction to be completed in the spring of 1979. Completion of the first 5 miles of effluent disposal pipeline in early summer 1978 enabled the District to make its first irrigation deliveries through eight on-farm turnouts.

The reuse system is unique in that it is operated as an irrigation system rather than a wastewater disposal system. Water is delivered to ranchers based on a pre-determined irrigation schedule, adjusted each year for cropping patterns, rainfall, etc. Wastewater flows are regulated by a 1,500 acre-foot reservoir so that water deliveries can meet irrigation requirements. Deliveries are made through 19 automated turnouts along the 9-mile-long outfall pipeline.

Each rancher has signed a separate contract with the District to take a specified quantity of water (dependent on irrigated acerage) each year during the irrigation season. The water is free but the rancher agrees to take the water for 20, 30 or 40 years. The contract is also binding on successive property owners. If a rancher does not take the water, The District may enter the land and apply the water as specified.

Another unique feature is the automated operation of irrigation turnouts. Solenoid actuated, hydraulically operated valves on each pipe turnout are operated remotely by command from a control panel at the central wastewater treatment plant. Commands are transmitted by radio signal and initiated on a keyboard at the treatment plant. Flow rates and totalized flows at each turnout can be displayed on a cathode ray tube screen upon command at the treatment plant control panel. Flow rates and liquid levels are also monitored by the computer-based telemetry system at other influent and effluent system checkpoints.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Long Term Effects of Municipal Wastewater Reuse on Cropland and Forestland

AUTHORS: William E. Sopper and Sonja Kerr

AFFILIATION: Penn State University

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

In 1963, a research facility was constructed to spray irrigate 0.5 mgd of chlorinated secondary-treated sewage effluent on cropland and several forest ecosystems. During the past 16 years (1963-1978) sewage effluent has been applied on these areas in various amounts ranging from 2.5 to 15 cm per week and over various lengths of time ranging from 16 weeks during the growing season to the entire 52 weeks. A comprehensive monitoring and research program has provided a continuing long-term evaluation of the effects of wastewater recycling on the vegetative cover (crops and forests), ecosystem stability, physical, chemical and hydrological soil properties, soil fauna, soil percolate water quality and groundwater quality, ecosystem renovation efficiency and wildlife. The results of these studies will be summarized and discussed. Emphasis will be placed on a discussion of recent emerging problems which might effect the long-term use of land for wastewater recycling.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Micro Gas Dispersions for Flotation Treatment of Wastewater For Recycling

AUTHORS: James Keane and Amos Shaler

AFFILIATION: Buchart-Horn Engineers

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

Laboratory flotations and solvent sublations done at the Universities of the Witwatersrand and of Rhode Island, at Bucknell University, and in-house, using micro gas dispersions containing various combinations of surfactants, depressants, salts, and precipitants, all at very low concentrations, have greatly extended the range of potential utilization of the flotation approach to the treatment of waste waters for discharge or recycling, and of drinking water supplies for purification and detoxification. Runs have been carried out with and without pretreatments for pH control, conditioning, and flocculation, with and without final clearing with sparged air, and with and without polishing by filtering through regenerable bricks of bonded-granular activated carbons and other adsorbents. The materials and methods for both flotation by micro gas dispersions and for adsorption by bonded granular adsorbents are patented.

A transportable pilot plant capable of treating 10,000 GPD has been constructed and put into service for evaluation of MGD treatment of waters on site. Results are reported for the treatment of various waters; they include the removal of lints and clays from laundry wastes for recycling purposes, the removal of humic, fulvic, and tannic precursors of halogenated alkanes from drinking-water supplies, and the separation of water from accompanying clays and other constituents in phosphate and coal slimes.

It is shown that heavy-metal contaminants can be brought down by factors higher than ten in single passes at fractional-ppm levels, that lints, oils and fats, and clays can be effectively removed from laundry wastes, that many refractory organics can be floated out of waste waters and drinking water supplies, and that mineral separations can be done in clay-containing slimes.

Micro gas dispersions are a very versatile means of introducing finely divided air and other gases (chlorine, ozone, CO_2, etc.), together with the necessary dissolved or suspended reagents, into flotation columns or in-situ unconfined flotation curtains. The bubbles do not coalesce on their way up the column, but are bridged to each other, so that their surface-to-volume ratio does not decrease and their rate of rise is much greater than that of bubbles of equal size generated by pressurization or by sparging. Consequently the group of processes collectively called micro gas dispersion flotation requires only short residence times. Since reagent concentrations are minimal, and very little mechanical energy is required in the preparation of micro gas dispersions, their use in water treatment appears to be economical in comparison with competitive processes for difficult recycling problems.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Chemical Analysis and Toxicity of Nonvolatile Organic Compounds in Wastewater

AUTHORS: Harold F. Walton and Clive Solomons

AFFILIATION: University of Colorado

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

The volatile organic compounds in water, those that can be removed by a stream of inert gas, have been studied by several workers. The nonvolatile compounds have received much less attention, because of the great experimental difficulties involved. We are studying these nonvolatile and less volatile compounds, concentrating them and separating them into fractions by the methods of liquid chromatography and measuring their toxicities by their effects on human blood cells.

The liquid chromatographic method uses the adsorptive power of "Bondapak-C$_{18}$", a highly porous silica, particle size 37 to 75 micrometers, coated chemically with octadecyl groups, $C_{18}H_{37}$. This absorbent retains the less polar, more hydrophobic trace organic compounds from water while letting pass the highly polar, highly soluble compounds as well as inorganic salts. We start the analysis by pumping a few liters of filtered wastewater through a stainless-steel column, 1 cm in internal diameter and 50 cm long, packed with Bondapak-C$_{18}$. The pH of the water is adjusted to control the retention of weak organic acids. The water flowing out of the column passes through an ultraviolet-absorbance detector, and the absorbance is recorded on chart paper. The highly polar organic compounds that are not absorbed, and that account for two-thirds of the total organic carbon, are "seen" in the detector. The column is then flushed with distilled water, which releases some compounds that produce an abrupt rise in UV absorbance; then the water is replaced with methanol according to a linear gradient, starting with zero and ending with 100% methanol.

The record of absorbance against time gives information about the range of organic compounds in the sample. The most polar compounds emerge first, including brown and green humic materials; less polar compounds come out later. The form of the graph allows us to assess the effects of different treatments. We find that activated carbon has little effect on the polar materials but does take out much of the nonpolar compounds, and it is these compounds that are the most toxic. Reverse osmosis removes ionized salts and highly polar organic compounds but lets pass some of the less polar materials.

The liquid flowing out of the column is collected in six fractions ranging from most polar to least polar, and each fraction is concentrated to small volume by evaporation. Typically, wastewater samples of 2-8 liters yield concentrated fractions of 3-4 mL. It is these fractions that are tested for toxicity, primarily by their effect on blood platelets. Health platelets will synthesize adenosine triphosphate (ATP) whereas platelets that have been damaged by contact with toxic substances cannot synthesize ATP.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Wastewater Reuse - Persistence and Variability of Contaminants

AUTHORS: Andrew J. Englande, Jr. and Robert S. Reimers, III

AFFILIATION: Tulane University

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

Desired quality of water for reuse will depend on the intended water usage. Reuse applications therefore will require emphasis in the removal of selected physical, chemical, and biological parameters to use-specific, non-adverse levels. Treatment plant operating experience has indicated several of these parameters to be difficult and expensive to remove with waste treatment technology as currently employed. Persistent constituents include: nitrogen (ammonia and NO_3), phenol, TDS, trace organics, fluoride, barium, and selected heavy metals.

The proposed paper will focus on these parameters and in particular trace metals which tend to persist through biological and physical-chemical treatment systems. Emphasis will be placed on factors which affect this leakage (complexation, redox - potential speciation, bio-activity, etc.). The state-of-the-art as it applies to removal of pertinent parameters will be addressed. Expectant removal efficiencies of specific unit operations for contaminants of concern, and the effect of influent variability on product water quality will also be assessed based on operating data from pilot and full scale waste treatment facilities.

Since reuse potential is greatly affected by variation in concentration of constituents, particular emphasis will be placed on effluent variability. Considerable variability of parameter values is generally experienced since effluent quality is affected by the composition of the raw wastewater, the concentration of specific pollutants, and the variability inherent in the operation of the specific biological - AWT facility. Design and operation considerations for defining and minimizing effluent quality variability will be discussed.

Results of the paper, specifically with respect to heavy metals reductions, show removal efficiency dependent upon the specific metal, the possible inorganic or organic complexing constituents, oxidation reduction potential, pH, carbon bioactivity, coagulant addition, ionic strength of carrier water and other operating and environmental factors. Due to these factors, heavy metals removal efficiency is plant specific. In general AWT and physical-chemical facilities produced effluents of excellent metals quality especially with respect to potable water criteria. Residuals of arsenic, cadmium, chromium, mercury, selenium, and silver were found to be 3μg/l, 2 μg/l, 20 μg/l, 5 μg/l, 20 μg/l, and 2 μg/l respectively. These values exceed potable water standards for selenium and mercury; ground water injection recommendations for selenium; and aquatic life criteria for cadmium, mercury, selenium, and silver. The important of adequate dilution capacity of the receiving water is therefore underscored.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Feasibility of Effluent Reuse in Boca Raton, Florida

AUTHORS: Victor J. Pujals

AFFILIATION: Ross, Saarinen, Bolton & Wilder (CDM) Engineers

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

In June of 1978, the consulting engineering firm of Ross, Saarinen, Bolton & Wilder (RSBW) was reatined by the City of Boca Raton to perform a preliminary evaluation of the technical and implementation feasibility of providing treated City wastewater effluent for irrigation to the Royal Palm Yacht and Country Club and the Boca Raton Hotel and Club (Arvida Corporation) golf courses and the nearby Camino Real highway median strips. All sites are located in the southeast section of Boca Raton in Palm Beach County, Florida.

These golf coureses depend on their own wells for irrigation water but are faced with the possible exhaustion of freshwater from their wells in the next 2 or 3 years.

The Biscayne Aquifer is the source of potable water for Boca Raton and most communities in Broward and Dade Counties to the south. Productivity from wells in the Biscayne Aquifer is in general very high compared to other aquifers throughout Florida. However, the enormous development experienced during the last several decades has seriously stressed this water source and the natural groundwater hydrology of South Florida. Saltwater intrusion has occurred forcing wellfields inland.

The reuse of treated wastewater for non-potable use is practiced by numerous municipalities throughout the United States but no in South Florida to any significant extent. As new government regulations are implemented and the idea of complete water management takes hold, the reuse for golf course irrigation is perhaps one of the most acceptable uses for treated wastewater effluent. This is especially so due to the large quantities of water and nutrients (fertilizer) required by the golf course turf, both of which are often economically available in treated wastewater.

The reuse of treated wastewater for irrigation in Boca Raton is a promising alternative to the development of new irrigation water sources. For Boca Raton, wastewater reuse is worthy of consideration for the following reasons:

A. The demand for potable water and the discharge of waste loads to the ocean will both be reduced.

B. Groundwater would be replenished with additional freshwater to counteract the saltwater front.

C. The demand on the aquifer would be somewhat curtailed, helping to maintain desirable water table levels.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Vision of Balance

AUTHORS: Marvin D. Thurber

AFFILIATION: City of Westminster, Colorado

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

The City of Westminster, Colorado, recently committed itself to a program of growth and resource management that is both simple and direct -- an approach which can assure a quality of life acceptable to all its citizens.

A suburban community situated northwest of Denver, Westminster has grown from a population of 19,500 in 1970 to approximately 47,000 in 1978. Its utility service area contains more than 65,000 persons.

About 10,000 acres, or 50 percent, of the land within the city limits are currently undeveloped.

In the semiarid west, successive use of water must, of necessity, be a part of any blueprint for the future. Thus the Westminster reuse plan provides a method whereby urban and rural residents are working together to obtain water in a form most suitable for their individual needs.

This innovative program, on-line since mid-1978, allows Westminster to exchange the effluent from its wastewater treatment plant for raw water for domestic use within the city.

Under the terms of an agreement signed in 1976, with the Farmers' High Line Canal and Reservoir Company, the City of Westminster takes raw water from the canal upstream into its reservoir at Standley Lake.

After treatment for domestic use, the water is run through the city's municipal water and wastewater system. A like amount of effluent from the Big Dry Creek Wastewater Treatment Plant is returned to the canal downstream via pipeline for use as irrigation water by area farmers.

Utilizing Westminster's effluent for irrigation of crops is not only cost effective for the farmer who is suffering from a fertilizer shortage, but is beneficial for his crops.

Virtually all plant nutrients essential to growth can be found in desirable quantities in the effluent. It not only meets stringent health standards, but has also been found to be superior to the water presently in the canal with respect to bacterial quality.

The Westminster plan has yet another advantage -- that of offering the farmer a regulated flow of irrigation water, especially beneficial during dry years.

Expansion of Westminster's treatment plant and construction of a pump station and force main, necessary to implement this program, were funded by 75 percent federal grant, thus making this the first federally funded successive use project in Colorado and one of the first of its kind in the United States.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Recreational Area Water Reuse System

AUTHORS: Roy A. Ackerman and I. A. Cosentino

AFFILIATION: ASTRE, Saxton Air Systems

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

A complete zero discharge sanitary system, incorporating physical, chemical and biological processes, has been developed and tested. This system, called the Enviropak® AWTP, is comprised of the following unit processes: equalization, gross particulate removal, a trickling filter, screening, mixed media filtration, activated carbon adsorption, disinfection, and storage.

Several major advantages prevail for this on-site system:

1. Unlike the other currently available systems, the AWTP accepts grey water (wash water), as well as black water.
2. The AWTP comes complete with a comfort station, containing sinks, urinals and toilets.
3. Water is only recycled for black water needs, thereby insuring the safe, non-toxic use by its patrons.
4. All excess water is evaporated using a novel process.
5. The evaporative system provides climate control for the comfort station (air conditioning and heating).

The AWTP installation, at Olney Park (Maryland), has been operating for over a year. Four similar systems were simultaneously installed in Bucks County (Pennsylvania). A pilot unit and a complete process model formed the basis for the design of these units, and those currently being developed.

The basic design, which can now be conveniently scaled up or down, accomodates 250 flushes per day (plus the attendant gray water). The flush water and the water from hand washing enters the aerated equalization basin. The basin is designed to accomodate loadings that may exceed the contemplated quantity in any given day. From the equalizer, the water is pumped to the gross particulate removal device.

The recirculating trickling filter (containing plastic mass transfer media), then performs carbonaceous oxidation and ammonia degradation. A shaker, with a smaller mesh size, then processes the wastewater, from which the water flows through a dual media filter, for further solids removal. The activated carbon columns remove dissolved organics from the water, which is then disinfected by iodine. The completely oxidized, filtered water is then stored in an aerated tank, thereby stripping out any potential odors, as well as providing further detention and mixing to insure adequate disinfection.

While this system is currently employed as a recreational comfort station, it can find utility for construction sites, mining facilities, as well as roadside rest areas.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Water Reuse for Irrigation - Gilroy, California

AUTHORS: Lloyd C. Fowler

AFFILIATION: Santa Clara Valley Water District

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

The City of Gilroy, California in conjunction with the Santa Clara Valley Water District is using its treated wastewaters for agricultural purposes. The facilities, completed in 1977, consist of treating 1.7 mgd of primary effluent in an oxidation pond, mechanical straining and chlorination in an 8 mile pipeline to a terminal storage reservoir. The first two miles of the 12-inch steel distribution main acts as the chlorine contact chamber. If adequate chlorine residual is not maintained, the system is shut down by an automatic control.

Along the 12-inch steel pipe distribution main is a three-pair control cable which provides information on reservoir elevation, valve position, flow rates and residual. The reclamation project water supplements the groundwater supply by making 1,500 acre feet of recycled water available for irrigation, leaving that much groundwater for use in homes, commerce and industry.

Total project cost was $1.8 million, and most financing was provided by a loan from the U. S. Bureau of Reclamation (USBR). Payback of the USBR loan and other costs will be through sale of the reclaimed water and contributions from the city and the two water districts.

The intended use of the recycled water is for irrigation of agriculture and landscaping. The agricultural units are primarily nursery crops, flowers, and seed crops. This market contains about 300 acres. The landscaping irrigation would be at a city park, the city golf course, and a new high school. These markets contain about 150 acres. To date, these users have contracted for 700 acre-feet per year.

All markets are furnished water under special contracts which provide for the delivery and payment of a minimum quantity of water. Additional quantities of water can be supplied if available. The contracts are for a term of 20 years. The price of water is $10 per acre-foot for water used for agricultural purposes and $40 an acre-foot for water used for municipal purposes (other than agricultural uses). The contracts provide for escalations in price should costs of operation rise.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Aerosol Generation in Sprinkler Irrigation

AUTHORS: Bahman Sheikh, Philip J. Morris & Joyce S. Hsiao

AFFILIATION: Engineering Science, Inc.

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

The possibility of transmission of water-borne pathogens through aerosols generated in sprinkler irrigation, especially when reclaimed water is used, has long been a public health concern. In the Monterey Wastewater Reclamation Study for Agriculture (MWRSA), a systematic study of aerosols and their bacterial content is being carried out. An optical scanning device was used to simultaneously enumerate aerosols in five particle size ranges over pre-set time periods. Nearly all aerosols generated were found to be smaller than 20 micrometres (μm) in diameter, with the majority in the 0.5 to 10 μm size range. A general, sharp decrease in the number of particles was observed with distance from the sprinkler lines in all but the smallest particle size ranges. The number of particles in nearly all size ranges remained fairly uniform within the range of normal human breathing height and began to decline at heights above four metres.

Background aerosol counts in the Castroville area are generally so high, due to humidity and fog conditions prevalent on most days, that a definitive delineation between natural aerosols and sprinkler-generated aerosol is difficult. Future tests will include tracer studies of aerosol travel as well as the bacteriological content of the aerosols, with the use of Anderson Samplers. These data will provide a baseline for later comparison with aerosols generated when reclaimed water is used in the same fields.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: The Dan Region Wastewater Project - Stage II

AUTHORS: David J. Farchill

AFFILIATION: Tahal Consulting Engineers, Ltd. - Israel

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

The Dan Region Wastewater Project is a comprehensive inter-regional scheme for the collection, purification and reclamation of the municipal wastewater generated within the Greater Tel-Aviv, Israel Metropolitan Area with two principal objectives:

1. To eliminate pollution along the Tel Aviv shore line; and
2. To recycle the reclaimed water to the arid region in Southern Israel, mainly for industrial and agricultural uses.

The raw wastewater will be collected and conveyed to a central regional treatment facility, approximately 10 km South of the City. The proposed facilities will ultimately serve 8 additional municipalities encompassing an urban service area of 200 sq. km., with an estimated (1976) population of 1.1 million residents, and including approximately 800 industrial and commercial enterprises generating a wide range of water borne industrial wastes. The overall system has been planned for a projected expansion to 1.3 million residents by 1985 and 1.7 million by the year 2000.

The treatment facilities and the main transmission system are currently under construction, involving a total investment of over US$ 65 million, through the completion of the 1985 stage of development. The transmission system, 18 km long, comprises sections of force mains and gravity flow lines up to 84 inches in diameter.

The proposed regional wastewater reclamation facilities will have an average treatment capacity of 116 million cu.m per year (84 U.S. MGD) by the year 1985, with provision for expansion to treat 160 million cu.m per year (116 U.S. MGD), after the year 2000.

The wastewater purification system will include, initially, secondary biological treatment and chlorination, with provisions for additional polishing and/or physical-chemical treatment, if required in the future. The biological treatment will consist of a modified low rate, activated sludge process, without primary settling, which will provide for efficient carbonaceous BOD/COD removal, nitrification and denitrification, and a high level of phosphorus removal, in a single sludge system, without exogenous carbon sources of chemical additions.

The modified biological process, developed by TAHAL especially for wastewater reclamation purposes, has undergone comprehensive technical scale demonstration tests at the project's Pilot Plant and Laboratory facilities in Tel Aviv for the past three years. The following average removal efficiencies were achieved for the modified activated sludge process: BOD_5 - 98%; COD - 91% - 95%; Nitrogen - 92%; Phosphorus - 70-73%; chlorine demand for full disinfection - less than 10 mg/l, because of the low levels of residual ammonia and carbonaceous matter in the final effluent. (Based on preliminary disinfection studies).

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Data Acquisition, Monitor and Control System for a Water Reuse Pilot Plant

AUTHORS: 1) Patrick Y Yang, 2) J. R. Gyorki, 3) W. P. Lambert & 4) M. J. Small

AFFILIATION: 1 & 2) Life Systems, Inc., 3 & 4) U.S.A.M.B.R.D.L.

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

A data acquisition system with control and monitor functions has been developed for a full-scale water processing system pilot plant. The pilot plant study has been carried out with the objective of collecting data for the complete mechanical, hydraulic, chemical and electrical design of a fully automated water processing system for the field Army medical facilities. The Data Acquisition, Monitor and Control System was designed to effectively achieve this objective. The system uses a distributed processing technique in which a functional and physical distribution approach was implemented to handle the following functions: (1) data acquisition, (2) data retrieval, report generation and program development and (3) real-time control and monitoring.

The system consists of foreground and background systems, a built-in monitor and a remote satellite controller with provisions to be expanded to 15 satellite controllers. The foreground system handles real-time tasks which require immediate system attention. The background system performs tasks which do not require real-time service and thus have lower priority in computer task scheduling. Control/monitor and data acquisition are real-time tasks and, therefore, are assigned to the foreground. On the other hand, report generation and data analyses are not real-time tasks and, therefore, are assigned to the background for batch processing. A remote satellite controller is a self-contained, computerized control/monitor instrumentation unit linked to the Data Acquisition, Monitor and Control System via communication channel.

There are three types of reports. The on-call report lists operator selected sensor data in engineering units with the date and time of acquisition. The 24-hour report lists the averaged sensor data, high and low peaks of data and the number of excursions beyond sensor setpoints. The command log report lists the operator initiated actions on the satellite controller such as modifications of scale factors, allowable ranges, setpoints and timing sequences and commands to activate/deactivate the water processing system.

The system was designed with communication links to six remote terminals with provisions for immediate expansion to eight terminals. Five of the terminals are within one mile of the mainframe system and were therefore designed with hardwired links. These remote links allow users at the remote terminals to operate the Data Acquisition, Monitor and Control System as if the operator were at the mainframe.

The system provides the user with the benefits of (1) reduced labor requirements in pilot plant operation, (2) reduced labor requirements in pilot plant data acquisition and retrieval, (3) increased effectiveness in the pilot plant operation and (4) availability of the system as a general purpose laboratory data acquisition and computing system.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Controlled Environment Aquaculture Wastewater Treatment

AUTHORS: Christopher R. Alsten

AFFILIATION: Solar Aqua Systems

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

Over the past two years, an innovative aquacultural wastewater treatment process has been evaluated with respect to removal of BOD, S.S., nitrogen, phosphorus, T.D.S. and other wastewater elements. The current demonstration "Solar AquaCell" facility consists of a series of three equal-sized, connected longitudinal tanks (8'x13'x6' deep, 4,000 gallons each), and final screening with a slow-sand filter to recycle biological organisms useful to the process. Flow rates have ranged from 2,000 - 4,000 gpd, with total retention times ranging from 3-6 days. The entire system is enclosed in an 1,800 sq.ft. solar heated greenhouse.

Basically, the Solar AquaCell system and process is a composite of the best design aspects of five well-proven sewage treatment technologies. These are:
1) Aerated Lagoons 2) Floating aquatic macrophytic plants 3) Submerged Activated Bio-Web Substrates 4) Greenhouse, solar pond cover 5) Solar heat exchange system

The treatment efficiency of this system along with its biological community and biomass productivity was examined for the 3,000 gals/day demonstration facility. With 4-6 day retention time, the system achieved removal efficiencies of 98% BOD, 99% suspenced solids, 100% nitrification, 70% TKN, 20% phosphorus, and produced an effluent very suitable for multiple reuse purposes.

Quantitative biological analysis of the system revealed dense and diverse growth of bacteria, diatoms, protozoa and algae on the leaves of plastic Bio-Web substrates.

Water hyacinth and duckweed standing crop varied from 26 Kg/m^2 to 10 Kg/m^2 wet weight and productivity averaged 0.68 Kg/m^2/day wet weight.

Energy requirements, for this process are approximately 1/3 that needed for activated sludge, and could be even further reduced in a large scale system. The projected construction and O&M costs of such a system scaled up to municipal size appears to be about 50% of conventional high technology systems.

Land needs are not great due to the greenhouse and superior winter operations. Approximately 1-2 acres/MGD is required to achieve secondary quality effluent, or 3-4 acres for advanced tertiary quality water in most temperate climates.

The high water quality obtainable by this system coupled with its flexibility, low cost, and pleasing esthetics (totally enclosed greenhouses) make it well suited for situations where wastewater reuse is desired.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Recreational Reuse at Lancaster, California

AUTHORS: Franklin D. Dryden

AFFILIATION: County Sanitation Districts of L. A. County

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

Lancaster is a city of about 40,000 people located in the high desert area at the northern edge of Los Angeles County. Annual rainfall averages a few inches per year, and water supplies are primarily derived from groundwater basins. In the late 1950's, falling groundwater levels made conservation of water a critical issue and use of groundwater for recreational purposes was prohibited.

Considering the attractiveness of water-based recreation, the County of Los Angeles proposed the development of recreational lakes utilizing reclaimed water from the Sanitation District 14 Water Reclamation Plant. At the time, about 4 MGD of wastewater from the Lancaster community was treated in oxidation ponds and disposed of by evaporation. In order to make the water suitable for use in recreational lakes, a research project was conducted by the Sanitation Districts of Los Angeles County and funded by the Public Health Service and Federal Water Pollution Control Administration. This led to construction of a 0.5 MGD tertiary treatment plant employing alum for precipitation of phosphate and coagulation of algae and sedimentation and dual-media filtration for their removal.

In 1971 water from this plant commenced filling the three lakes which were the nucleus of Apollo County Park near Lancaster. Apollo County Park is on a 56-acre site developed on alkaline soils that required extensive reclamation before they could be landscaped. The parks are still in use with an active fishing, boating, picnicking and recreational program. This paper will review the wastewater treatment process and water quality problems experienced in the operation of Apollo County Park.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Towards a Cellular Assay for Water Toxicity

AUTHORS: Joseph A. Boccia and Gunter F. Bahr

AFFILIATION: Armed Forces Institute of Pathology

DATE OF SESSION: Tuesday, March 27 *SESSION NO:* Poster

A bioassay estimating the toxicity of water for animal cells in culture is being investigated at the Armed Forces Institute of Pathology. The microscopic, anatomic alterations which take place in animal test cells, exposed for variable times to different concentrations of model toxicant, are being quantitatively studied. It is prposed that chemically non-pathognomonic, but reproducible, anatomic changes occur in test cells exposed to substances presumed noxious to whole organisms. The test cell's response to chemical injury is a graded function of exposure time and toxicant concentration. It is or practical importance to determine whether these changes can be detected mechanically before being manifest to vision.

A computer assisted, light microscope system has been developed as a reserach tool enabling computerization of test cell pictures. These are called digital images and are obtained from cells having been fized in ethyl alcohol, biologically strained, and magnified by light microscope. Cells for which such pictures are obtained are selected from parent populations exposed in vitro to differing toxicant concentrations and for variable lengths of time. A complete series of pictures for cells exposed to 2,4-dinitrophenylhydrazine and a series of cells exposed to RO permeate concentrate have been recorded on magnetic tape. Subsequent analysis of these pictures will be performed using the same minicomputer system which assisted their acquisition.

Analysis consists of making measurements on the test cell pictures. Multiple measurements can be made using the computer picture of each cell in turn. The resulting statistics are compared among the various experimental and control population samples. Measurements of this type are called reatures. Features are sought which contribute strongly to the distinction of normal from intoxicated cells and among those at different levels of intoxication. The ultimate goal is a cytologic assay of residual cytotoxic potential in water based upon the quantitative evaluation of cytomorphologic changes induced by exposure to test water bearing potential toxicants.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: General Purpose Dynamic Simulator for Water Reuse Systems

AUTHORS: Cecil L. Smith and Warren T. Abbott

AFFILIATION: Louisiana State University

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

Unit processes such as ultrafiltration and reverse osmosis utilized in water reuse units are characterized by cyclical operation, such as 20 hours on-stream and four hours regeneration. Furthermore, many potential applications of water reuse units are characterized by non-steady feeds. An example of this is a water re-use unit supporting a field military hospital, wherein the fresh water requirements and the waste water effluents var widely during a 24 hour period. The dynamic process simulator tailored to water reuse preocesses is the outgrowth of the design of a re-use unit by the U.S. Army Medical Research and Development Command.

As a variety of water re-use applications are envisioned, the development effort was directed toward a general purpose simulator for re-use units. The configuration of the unit is specified by the input data, along with the parameters that specify the characteristics of the individual items of equipment in the unit. The stream vector concept of the flowsheet simulators such as Flowtran was adopted as opposed to the analog-computer-emulation approach used by the traditional general purpose digital simulation packages.

The simulator package includes modules such as mixed tanks, stream splitters, pumps, etc., that are commonly found in all process systems. Presently, the simulator includes modules for ultrafiltration, hollow-fiber reverse osmosis, ozonation, and hypochlorinatio that are specifically oriented to water re-use applications. Work is presently underway on a model for a tubular reverse osmosis unit.

Although models are generally available for most of the unit processes, many parameters (such as permeability coefficients) must be evaluated for each specific waste water. The overall procedure involves collecting the required performance data from an experimental laboratory unit, determining the required model parameters from this data, and then making the simulation.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Sonics and Electrostatics - An Innovative Approach to Water & Waste Treatment

AUTHORS: 1) Robert S. Reimers, 2) D. Blair Leftwich & 3) Paul S. deKernion III

AFFILIATION: 1 & 2) Tulane University, 3) Sonic-Clean, Inc.

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

With the increased demand for water, any water treatment process requiring little to no chemicals is a conducive alternative for many industries. This is especially pertinent when the possibility of water reuse is considered. The application of an ultrasonic-electrostatic water treatment process has demonstrated reductions in operational and maintenance problems along with the improvement of effluent water quality. The reuse potential for this instrument has been noted in the soft drink bottling industry, wastewater treatment plants, and cooling tower systems. The objective of this paper is to elucidate the effectiveness of this instrument in various industrial applications and its possible water reuse potential.

The specific process under discussion incorporates two physical regions, a hydrofracture and an electrogenerator region. In the hydrofracture region, the hydraulic flow is optimized and the ultrasonication is applied to the aqueous solution throughout the whole system. Within the electrongenerator region, the water flows through an induced electrostatic force field. Due to this treatment, molecules are made unstable by adsorbing electrons. These unstable compounds inhibit the formation of precipitates, disintegrate existing scale (to soluble salts and sludge slurries), reduce bioactivity and contamination, and convert soluble organics to less soluble detergents.

Concurrently, preliminary research is being conducted in the field on the treatment of secondary effluents. The application of this process has yielded some interesting phenomena. This process was found to reduce the BOD by 50 percent and total coliform by 70 percent as a function of both flow and initial concentration. Before this process could be considered as a viable tertiary treatment system, the effects of temperature, suspended solids, and acclimatized biogrowth must be ascertained and resolved. Even so, this process has the potential for reducing the oxygen demand of a secondary effluent by 50 percent and the chlorine demand considerably. This resulting effluent could easily be used for irrigation water. There has been come speculation that this ultrasonically and electrostatically treated water may actually induce greater plant growth.

From various field tests, the Aqua Scrubber has been applied to both once-through and recirculating cooling towers. Due to the high salt levels, the recirculating cooling tower water was not reusable, but the once-through cooling tower effluents appear amenable to irrigation, etc. This is due to the lower disinfectant requirements, elimination of the need for descaling agents, little or no need for anti-corrosive agents, such as, zinc or chromium, and a reduction of soluble salt levels to less than 300 mg/l.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Increasing Water Supply for Home Irrigation

AUTHORS: Barney P. Popkin

AFFILIATION: The University of Arizona

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

In the arid and semi-arid American Southwest, low rainfall and humidity and high evapotranspiration make irrigation necessary for domestic plant growth and commercial crop production. Irrigation water is restricted to dwindling groundwater supplies and rainfall-or snowmelt-dependent streamflow. Both sources are susceptible to droughts and overdrafts.

A large percentage of the potable water used in the Southwestern home is used for irrigation of domestic gardens and yards. Another large percentage is returned to sewers for sewage treatment. Water fees increase because of dwindling water supplies, increasing depths to groundwater, scarce surface water, and high water-treatment costs. Sewer-use fees increase because of high construction and wastewater-treatment costs. Both water and sewer-use fees increase because of rapid urban expansion and increased water-quality standards. As these fees increase, supplemental home irrigation sources will become attractive and will be sought.

Major supplemental water sources are grey water, harvested runoff, and roof runoff. Grey water is all home sewage effluent other than from toilets; it includes effluent from sinks, showers, tubs, dishwashers, clotheswashers, swimming pools, and evaporative coolers. Harvested runoff is all water produced from specially landscaped or prepared surfaces, such as driveways, streets, walks, or treated land surfaces. Roof runoff is all water produced by rainfall that drains off a roof. The amount of grey water depends on the family's size and habits. The amount of harvested runoff depends on size, slope, soil's and material's properties, and rainfall. The amount of roof runoff depends on the size and geometry of the roof, and on rainfall. The quality of grey water (though highly variable), harvested runoff, and roof runoff is generally suitable for home irrigation.

Engineering systems are required to collect, store, treat, distribute, and apply supplemental home irrigation water. There are many possible combinations of systems, but the most preferred ones will have low capital expenditure and low energy requirements.

Economic considerations are reviewed on large and small scales. Large-scale analysis indicates that a large and significant reduction in municipal costs and services is possible if supplemental irrigation water is developed for the home. Small-scale analysis for the 100-unit trailer park, 50-unit two-story apartment complex, double family home of six, and single family home of three, indicates that costs are favorable for supplemental irrigation systems, particularly for future large-scale units in the Southwest.

A research program is suggested. It emphasizes field trials and demonstration projects which test the design, operation, maintenance, and economics, as well as public and institutional acceptance of supplemental home irrigation systems.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Rapid Detection of Bacteria in Treated Wastewater

AUTHORS: Judith F. Kitchens, Randall S. Wentsel, Ralph S. Valentine, Patricia E. O'Neill
AFFILIATION: Atlantic Research Corporation

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

This paper describes the results of work in progress at Atlantic Research Corporation for continued development of the Reverse Phage Titer Rise Reaction (RPTRR). The RPTRR test was originally developed in 1969 as a means for rapid (2-6 hour) determination of the presence of bacteria in water. The test is based upon specific detection of bacteriophage, which are viruses that infect bacteria. The phage count can be related quantitatively to the population of coliform bacteria in the water sample.

Under sponsorship of NSF, the RPTRR test was evaluated by various cities throughout the United States. Results of these field tests indicated a significant and consistent correlation between bacteria and phage in natural waters. However, the phage/bacteria relationship was found to be significantly different in treated wastewaters. Phage appear to be much less susceptible to disinfection with chlorine. As a result, the phage/bacteria ratio was found to be up to 2 orders of magnitude higher in treated waters than in natural waters.

Current efforts involve defining the sanitary significance of the presence of bacteriophage independent of their relationship to bacteria. Under NSF Grant FFB78-19196, the populations of various phage types in treated and untreated waters are being enumerated. The phage counts are a function of the treatment processes and the source of the water. Since phage are more resistant to disinfection processes than bacteria, enumeration of phage may be a more meaningful measure of the sanitary condition of water after treatment for recycle or reuse. Evaluation of the relationship between bacteria and phage in both treated and untreated waters is another objective of the study. Still another purpose is to provide a better understanding of the fate of both bacteria and phage in natural waters and treated waters. Evaluation of the distribution of phage types will aid this understanding.

Since phage are more resistant to disinfection, they may also provide a means for inferential determination of the presence of animal viruses. If this can be verified, it would represent a significant advance in water monitoring technology.

The capabilities of the RPTRR test as described above appear to have application to water reuse. Water reuse is dependent upon economical treatment to desired sanitary standards. The RPTRR test provides a simple, inexpensive means of evaluating water quality within 2 - 6 hours. Rapid feedback of water quality data permits almost real-time capacity to make processing adjustments that will insure efficient, effective treatment.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Toward the Goal of Direct Water Reuse - What Should We Do Next?

AUTHORS: Ju-Chang Huang

AFFILIATION: University of Missouri - Rolla

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

Direct water reuse is a relatively sensitive issue among the American public today. This is partly due to the long-standing reluctance on the part of governmental regulatory agencies to approve such a practice, and partly due to the inadequate communication between the scientific/technical personnel and the general public concerning the tremendous technical advancement recently achieved in the field of water and wastewater purifications. As a result, the public is still deeply embedded with such a feeling that "as long as it is wastewater, it is always dirty, unsanitary, and unfit for human use no matter how thoroughly it has been treated". However, is such a feeling justified from a scientific viewpoint, or is it purely a matter of psychological reasons? Will the treatment technologies available today enable us to achieve direct water reuse at a reasonable cost, without endangering the public health? Is there a need for special precautions in practicing direct water reuse for the drinking purpose? These questions will be discussed in this paper.

Current available technologies for advanced waste treatment will be briefly reviewed and the treated effluent qualities for such technologies as obtained by the author and others will be used as a focal point of discussion on the feasibility of practicing direct water reuse. Specific examples will be pointed out to demonstrate that today's public reluctance and skepticism toward direct water reuse is largely a matter of psychological unpreparedness rather than technical inadequacies. To overcome this psychological hangup, intensive public education with full government support will be needed.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Reduction of Potable Water Demand in the Arctic by Reuse of Sewage Effluent

AUTHORS: David E. G. Bromley, A. Benedek

AFFILIATION: James F. MacLaren Limited, Canada; McMaster University

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

As the need to tap the Arctic resources increases, the characteristics of the Arctic inhabitant will change, and as a result, the needs and services demanded by the inhabitant will become more sophisticated.

This particular paper discusses a research project which was undertaken by the authors to develop a sewage treatment process which was suitable for Arctic application. Two constraints affected the development of this process:

1. Sources and quantities of potable water in the Arctic are very limited.
2. The availability of skilled labor for construction and operation is difficult to obtain.

Thus the prime objectives of the project were to develop a sewage treatment system which:

a. could treat concentrated sewage flows resulting from low water usage sewage conveyance systems.
b. could provide sufficient treatment that the effluent from the system could be reused as sewage conveyance water and/or general household washwater.
c. would be easy to construct and operate.
d. would satisfy the Arctic user's requirement.

Upon consideration of the negative and positive aspects of the two basic processes, biological and physical/chemical system, it was decided that a combination of both would satisfy the requirements of the proposed treatment system.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Effluent Reuse in a Semi-Arid Region of the U.S.

AUTHORS: Gary R. Windolph and Timothy J. Carlson

AFFILIATION: C-E Maguire Engineers

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

The benefits of reuse are potentially the greatest in water-short or semi-arid regions. However, it is in these same areas that existing laws and agricultural practices hinder the implementation of wastewater reuse plans which provide for maximum benefits to be derived in the form of resource recovery.

This paper discusses the many economic and legal constraints which were encountered durin the completion of a reuse plan for the City of Sterling, Colorado. A unique solution was developed and is discussed in detail, including alternative evaluation, project benefits, and program implementation.

The City of Sterling, Colorado is a typical community of 12,000 located in the semi-arid, agriculturally rich, high plains of the eastern slopes of the Rocky Mountains. The desire to make maximum use of the treated effluent prompted the City Administration to study numerous disposal and reuse alternatives including year round discharge to the South Platte River, seasonal storage in and recovery from subsurface acquifers, sprinkler irrigation, and direct surface application. In total, eighteen different plans were evaluated on legal, social, economic, and environmental factors.

The selected plan includes summer discharge directly to the South Platte River which is necessary to satisfy the water demands of downstream water rights owners. During the winter, when surplus or free water exists within the river, discharge is to the alluvium of the river in a location from which the return flow (stream accretion) is available during summer months when shortages of water exist in the river. This stream accretion can be used by the City for augmentation of its own water rights or leased to other organizations for similar purposes.

The solution developed for this community has potential application in many locations throughout the country and offers a low initial-cost reuse system which conserves many of the resources normally lost through conventional disposal methods.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: A Preliminary Analysis of the Political Tensions Affecting Planned Reuse of Water in the Colorado River Basin

AUTHORS: Loretta C. Lohman

AFFILIATION: Denver Research Institute

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

This paper draws from several years of study of the management strategies for the Colorado River and of the policy aspects of planned water reuse in the Colorado River Basin. One study, sponsored by the U. S. Environmental Protection Agency, Region VIII, focused on an analysis of state and local management actions which might be taken to reduce salinity in the Colorado River. The Office of Water Research and Technology sponsored another study which examined the system of control, planning and management of water resources in the semi-arid Colorado River region as it applies to planned reuse of that scarce resource.

Unplanned reuse is a regular occurrence as the Colorado River flows over 1,400 miles of weathering soils and rocks before it enters Mexico. Increasing salinity, both from natural and man-created causes, as well as inadequate supplies to meet the demands of a developing region, are also factors in managing the Colorado River. Given these conditions it is likely that planned reuse of water in the Colorado River Basin might not only increase beneficial utilization of existing supplies, but might also improve water quality if known supplies of low quality water are tapped for consumptive reuse.

The technological and economic problems of the reuse of low quality water are the subject of much research and are fairly well identified. Legal barriers are identifiable, and are also the subject of specific research. It is the institutional barriers to planned reuse, as affected by the political processes supporting them, which have been scarcely examined.

Management of the Colorado River's resources is in the hands of a number of federal and state agencies which have frequently incompatible goals and policies applicable to satisfying demands for water use and for water quality. Setting aside statutory obligations, the administrative policies and regulatory interpretations of these agencies which can encourage or impede planned reuse are supported by agency or individual political perceptions. In addition, the tensions created by differing missions and/or constituencies can lead to political machinations in place of essential cooperation.

With the exception of California, every state in the Colorado River Basin has placed responsibility for water allocation and water quality in the hands of different agencies. Federal assignment of responsibility, at least in direction to the states, is similarly divided. The simple need of an agency and its leadership to establish a "turf" is a prime ingredient in creating political conflict, particularly when the missions of preserving and improving water quality and obtaining the greatest utilization are so often incompatible. Despite the inherently adversary role of water management in the Colorado River Basin, planned reuse has occurred and will probably continue to occur.

Brief summaries of the political interplay involved in a successful and an unsuccessful reuse project will be provided.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Evaluation of Health Effects Data on the Reuse of Shower and Laundry Waters by Field Army Units

AUTHORS: David R. Cogley and James C. Eaton

AFFILIATION: Walden Division of Abcor, Inc. U.S.A.M.B.R.D.L.

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

Health effects data on the reuse of shower water and laundry waters by field Army units were evaluated in a four-task program. In Task 1, a list of components was derived for a series of health care products. The principal objective was to determine typical ranges of composition for these health-care products, thus allowing for a sensitivity analysis in addition to point estimates of health effects. In the second task, an engineering evaluation was performed on the treatability of these components at concentrations expected in laundry and shower waters. Products formed during wastewater treatment were also considered. Unit processes considered for this task included filtration, ultrafiltration, reverse osmosis, chlorination, activated carbon adsorption, ion exchange, and the U. S. Army ERDLator. Eighty and ninety-five percent water conversions were considered. In Task 3, dermal, ocular, and oral toxicities of wastewater components were evaluated for concentrations expected in wastewater treatment systems. Finally, in Task 4, earlier Army-sponsored research was evaluated. The final program results will be discussed.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Virus Concentration from Waters by Hollow Fiber Ultrafiltration: The Importance of Hydrodynamics

AUTHORS: 1) Georges Belfort, 2) Elie Katzenelson, & 3) Yael Rotem-Borensztajn

AFFILIATION: 1) Rensselaer Polytechnic Institute , 2&3) Herbrew University - Jerusalem

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

The potential health dangers associated with direct and indirect water reuse for drinking are the cause of much concern and current research efforts. The possible presence of very low concentrations of pathogens including viruses in drinking water sources has suggested the need for innovative concentration methods.

Several methods have been used as a first step to concentrate model and other viruses from large volumes of water for enumeration purposes. These include adsorption-elution (1,2), coagulation (3), phase separation (4) and membrane filtration methods in general (5). We have devoted our attention to hollow fibers or capillary ultrafiltration membrane methods because of their compact size (high surface area/unit volume), well controlled hydrodynamics (for bore-feed flow), commercial availability with different membrane materials and molecular weight cut-offs, and finally, their ability to concentrate large volumes (up to 100 ℓ so far) of model polio virus I from deionized and tap water in short periods (1 to 2 hours) without allowing the virus to permeate the asymmetric hollow fiber membrane (6,7).

The performances of poliovirus I concentration from tap water using three different hollow fiber ultrafiltration modules are compared. Analysis of the results in terms of the virus/fluid dynamics in the hollow fibers is presented. Virus retardation (and adsorption) is explained via a particle-capture force balance and described by convective cross-polarization fields as a function of Peclet numbers. The effect of virus-suspended solids association on virus recovery is discussed. Finally, temperature effects and membrane fouling models (i.e. the back diffusion model and the adsorption-amology models) are used to help explain flux degradation with duration of the experiments.

A crucial element in optimizing mass transfer processes is the ability to understand and control the fluid dynamics of the system. This is the subject of this paper with the emphasis on virus recovery by hollow fiber ultrafiltration.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Urban Water Management - WATMAN

AUTHORS: Arun K. Deb and Richard L. Hillman

AFFILIATION: Weston Environmental Consultants

DATE OF SESSION: Wednesday, March 38 *SESSION NO:* Poster

With the growing needs of urban water demand and the decreasing availability of good quality sources, it is apparent that efficient and economical management of water is an essential step in long-range water planning. In water problem areas, in order to develop an optimum water plan and to safeguard the public health, it might be necessary to consider more than one raw water source, and more than one supply system.

This concept would produce a large number of alternative plans for supplying water for a city or region. Many of these possibilities can be readily dismissed on the basis of engineering judgment and local conditions. However, a substantial number of alternatives will require full analysis and evaluation before selection of a final plan. With a grant from the National Science Foundation, Weston developed a WATer MANagement (WATMAN) model which provides technical and economic evaluation of various alternatives of long-term planning and management of urban water system, and helps urban water and wastewater managers to find the most economical and implementable plan for their cities.

Since only a fraction of water used in a city supply must be of primary drinking water quality, two or more qualities of water could be supplied economically through separate distribution systems to meet various demands. Water reuse would be an essential consideration in the future of developing any long-term water management plan for a city, industry or region.

If all these options are considered, the urban water management system will be a complex one. The WATMAN model developed by Weston will provide analysis of all complex options of water management. It is flexible and can be used to analyze all feasible configurations of water systems including conventional, dual or multiple supply.

The maximum limits for the computer model are:

a. three qualities of water supply sources
b. 10 communities in a region
c. 50 unit operations or processes
d. A 30 year planning period

Specifically, the systems computer model uses water demand and preliminary design of physical components to determine a cost of collection, transmission, treatment, and distribution of single and multiple water supplies. Using variables such as demand rates, individual unit-cost functions, interest rates, and inflation rates, the model calculates component and total costs. The procedure converts the capital, yearly operation and maintenance, replacement, and salvage-value costs into an equivalent cost for the planning period representing the current investment required to satisfy all identified project components. The system also provides summary cost information for a planning alternative. At present, this model can only be used as a planning tool.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Total Wastewater Reuse at McClellan AFB

AUTHORS: Curtis J. Schmidt and Ernest V. Clements

AFFILIATION: SCS Engineers

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

A series of projects were completed for the U. S. Air Force during the period 1974-77 to investigate the potential for wastewater reuse within Air Force Bases. Treatment techniques and water quality criteria were developed to allow cascading of wastewaters from one activity, i.e. plating shops, to other activities, e. g. cooling tower make-up. A computer program was developed to allow rapid screening of potential reuse schemes and economic feasibility at any Air Force Base of other military installation.

McClellan AFB, CA was found to have excellent wastewater reuse potential, and a comprehensive investigation indicated that the base can reuse virtually all of its wastewater at a life cycle cost savings of several million dollars. Subsequently, SCS Engineers was awarded a contract to prepare design drawings and specifications for construction of tertiary treatment facilities and a dual distribution system. Treatment includes physical-chemical processes, filtration, and phosphate removal. Uses for the reclaimed water include:

- Cooling water make-up of approximately 40 towers
- Jet engine test stand cooling and noise suppression
- Acid fume scrubbers
- Autoclave cooling
- Paint water walls
- Sandblasting
- Vehicle and aircraft washing
- Irrigation of athletic fields and landscaping

Irrigation accounts for approximately 50 percent and cooling tower make-up approximately 30 percent of the 1.4 mgd reclaimed water use.

Interesting aspects of the project include the favorable economics (which undoubtedly also exist in other military and civilian situations), the engineering of the dual distribution system (over 10 miles of pipeline, 10 MG of storage, sophisticated monitoring and controls, etc.), and the multiple uses for the reclaimed water. An important bonus is the annual conservation of 500 MG of fresh water formerly withdrawn from the groundwater basin. Historical overdraw at this aquifer is evidenced by reductions of 6 to 8 feet annually in well water levels.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Reclaimed Wastewater as a Feasible Water Resource for Landscape and Orchard Irrigation
AUTHORS: William R. Everest and Robert A. Paul

AFFILIATION: PRC Toups Corporation, Goleta County Water District

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

Wastewater reclamation, as a feasible water supply for both landscape irrigation and irrigaton of citrus and avocado orchards, has been investigated for the Goleta area of the Santa Barbara County, California. The demand for wastewater in the study area has exceeded the yeild of the supply sources presently available to the Goleta County Water District. Previous water resources management and reuse feasibility studies have demonstrated the overall feasibility of wastewater reclamation for irrigation in the Goleta area. The first 201 facilities plan for wastewater reclamation by agricultural irrigation funded under the State Water Resources Control Board's Clean Water Grant Program has developed a cost-effective wastewater project for the Goleta service area.

The proposed project will eventually reclaim over 8 mgd of wastewater of which approximately 7 mgd will be utilized for agricultural irrigation. When implemented, the Goleta project will be one of the largest planned reuse systems in the United States.

Stringent water quality requirements for irrigation in the Goleta area necessitate very high levels of treatment prior to reuse. Irrigation of parks, golf courses, and other landscapting require tertiary coagulation, filtration, and disinfection of secondary effluent to comply with the California Department of Health reuse criteria. Avocado and citrus crops are extremely sensitive to high mineral content in irrigation waters. As a result, desalination of wastewater prior to reuse for agricultural irrigation is required in the Goleta to prevent crop damage to the highly profitable avocado and critus groves.

A key aspect of the Goleta program is a user participation program. Informal workshops and meetings have been conducted with potential agricultural users focusing on key issues such as the trade-off between additional water supplies and possible crop yeild reduction, mineral water quality requirements, reliability and cost of supply, reasonable assurances to accept reclaimed water, and the maximum cost of reclaimed wastewater which the agricultural community can afford and still maintain profitable operations.

A 5,000 gpd pilot project has been implemented with State and Federal assistance to demonstrate the feasibility of wastewater reuse for agricultural irrigation in The Goleta area. Existing primary effluent is providing additional treatment by biofiltration with artificial media, clarification, dual-media filtration, and reverse osmosis desalination. Product water from the pilot plant is hauled to a local avocado grove for irrigation through a drip application system. The pilot project will provide information on specific treatment requirements prior to wastewater desalination, removal of key water quality parameters by desalination, and potential full-scale utilization of water-saving drip irrigation for reclaimed wastewater application.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Open-Channel Ultrafiltration Spiral Module for Water Use

AUTHORS: Joseph A. Pisani and Frans Velterop

AFFILIATION: Envirogenics Systems Company

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

While several types of ultrafiltration modules and membranes have been developed for water reuse applications, it has become evident that the limiting factor in improving economics and productivity has been the membrane system geometry and the resulting flow dynmics obtained with the aqueous stream to be treated. For example, in the treatment of kraft paper mill effluents with conventional spiral wound elements, a low cost factor is achieved, but irreversible particulate collection within the membrane element reduces flux significantly and causes a flow maldistribution within elements and between elements in parallel, further aggravating plugging by particulates. Tubular systems, on the other hand, have unrestricted flow channels and do not experience the plugging phenomena observed with conventional spiral elements. Although tubular membranes function very satisfactorily in the presence of suspended solids, the system cost is slightly more than two times as high as spiral wound systems due to the very low membrane area packing density obtainable and the expensive pressure containment requirement. In addition, the operating cost of tubular systems in terms of power is higher than spiral modules because of the need to recycle the feed solution several times in order to achieve high product water recoveries.

The new type of module to be presented in this paper embodies the best attributes of both tubular and spiral wound geometrics while eliminating their main disadvantages. It is comprised of a thin, open-channel geometry to achieve high product water recovery and eliminate plugging and is wrapped in a compact module cartridge form for high membrane area packing density and low cost. The feed enters this module at one end of the center tube and, due to a plug inside the tube, is forced through a slot in the tube into the membrance sandwich. The feed then flows over the surface of the membrane within the thin, open-channel area formed by spacer strips. When the feed reaches the outer end of the leaf, a porous section in the center divider strip allows the feed to cross over to the other side and return to the center tube. It then flows through the slot in the tube and out of the opposite end of the tube from which it originally entered. The product water flows transverse to the feed flow, and exists at the ends of the module through the unsealed edge of the product water transport material.

As a result of the ease of fabrication and high membrane area packing density for this module design, the production cost is equal to or only slightly higher than conventional spiral elements. Therefore, the system cost for an open-channel spiral module system should be far less than for tubular systems but will allow for application in those wastewater treatment areas limited to tubular and not amenable to conventional spiral wound UF systems.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Water Reclamation and Reuse in the Power, Petrochemical and Mining Industries
AUTHORS: Louis J. Kosarek

AFFILIATION: Trace Metal Data Institute

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

Water has become a critical parameter to industry because of diminsihing availability, deteriorating quality, and government dictated effluent discharge limitations. A key aspect to alleviating this unprecendented situation is the incorporation of industrial water reuse, recycle, and reclamation to maintain a reliable water source and ascertain a zero discharge capability. A field proven means to incorporate total water reuse in industry is the application of High Recovery Reverse Osmosis Technology (HRROT). The HRROT system utilizes 1) specially designed prefiltration, 2) chemical pretreatment to maintain supersaturated brines and circumvent scaling, 3) pH control, 4) membrane separation technology and 5) a recycle loop to maximize water recovery. The power generating industry which requires water for such functions as boiler make-up, NO_x and SO_2 scrubber make-up, cooling tower operations, gas turbine injection, and potable sources for employees utilizes a vast quantity of water. The amount of water usage and the subsequent discharge volume is directly related to influent water quality. The use of high quality recycled water circumvents the primary supply problems and establishes a zero discharge capability. The water requirements of the petrochemical processing industry are: steam for various functions, cooling towers, plus water devoid of metal contaminants, total dissolved solids and organic derivatives. The effluent streams from such activities can be purified, recycled, and overall plant water requirements reduced with a minimum of discharge. The mining industry utilizes water in most non-pyrogenic processes and faces effluent discharge problems based upon inorganic, organic, and radiometric contamination of effluent process water, seepage from impounded water, deterioration of in-situ facility aquifers, resin regeneration brines and mine dewatering or drainage. The incorporation of the HRROT mode of purification and recycle retains a high level of water reclamation, increases the efficiency of water use, provides an excellent source of purified water and retains a zero discharge capability. The HRROT approach of water reuse has proven very efficient in the aforementioned industries.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

WATER REUSE SYMPOSIUM

TITLE OF PAPER: Administrative Steps to Regional Water Reuse Study, Los Angeles, California

AUTHORS: Wayne E. Kruse

AFFILIATION: City of Los Angeles - Water and Power Department

DATE OF SESSION: Wednesday, March 28 SESSION NO: Poster

The poster will briefly summarize the Orange and Los Angeles Counties Water Reuse, (OLACWR) Study and the sequence of events leading to its formation. The independent activities of the agencies involved and the role of regional, state and federal agencies will be described. The poster will complement a formal paper on the regional reuse study.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: A Laboratory Study of Radio-Labeled Virus Uptake by Soils

AUTHORS: Michael M. Reddy, G. W. Fuhs, R. Moore, L. R. Sturmann & D. H. Taylor

AFFILIATION: New York State Department of Health

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

This study was undertaken to identify the factors affecting virus uptake and release from different soils treated with wastewater. Chemical and biological mechanisms of virus adsorption and inactivation are being examined. In the initial phase of the project a procedure has been established to measure virus adsorption and desorption to particulate matter in soil-water suspensions. The virus was labeled with ^3H or ^{14}C in its coat protein and supernatants were assayed for radioactivity and infectivity. Five different virus groups are being studied; results with poliovirus (type 2) are largely completed. Suspensions of radio-labeled poliovirus were equilibrated with 32 soils and soil constituents. Eleven to 99.9% of virus were removed from solution (0.5 g of soil and 1 ml of an artificial freshwater). The average virus removal from both radioactivity measurements and from infectivity assays was 96%. In some cases virus removal measured as a loss of infectivity was significantly greater than removal measured as loss of radioactivity suggesting that some soils may inactivate, as well as adsorb virus or may cause aggregation of virus particles. Work is underway to distinguish between these possibilities. Adsorption of poliovirus to Ottawa sand is rapid, only partly reversible, and dependent on solution ionic composition and pH. The Freundlich and Langmuir equations, adequately describe the results at low and high virus concentrations respectively. From a Langmuir analysis an apparent maximum surface concentration of about 2×10^6 pfu/mg was obtained. Soil surface area may be a major factor in regulating virus uptake during wastewater application to land. In addition, certain soils and minerals are clearly more effective than others in removing virus, although correlations with chemical properties are weak. Sand overgrown with bacteria (and therefore coated with bacterial exopolymer) adsorbs less virus than mineral sand, and the same may hold for certain soils with high organic content.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Redux - Water Recycling System

AUTHORS: Robert W. Claunch

AFFILIATION: The Redux Corporation

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

The Redux Corporation, a wholly owned subsidiary of Arundale, Inc., of St. Louis, has been formed to engineer, manufacture and sell the Redux^{TM} water recycling system, a physical-chemical process which has been under development since 1974. Several models and prototypes have been built and tested to recycle laundry water in hospitals, institutional, and commercial laundries. In 1978, the first production model was placed in a commercial laundry in Boulder, Colorado. This system has been closely monitored for over six months to obtain data on operating cost, water quality and laundry product quality.

The success attained in recycling water from a commercial laundry has led to the evaluation and planned use of the Redux system to recycle grey water. The recycling of all "grey water" from a multi-family residential unit is one of the situations under consideration. Skin and eye irritation tests and ingestion tests are now being conducted on recycled water from the laundry. Some of the data is available at this time and is presented in the paper. A search for water quality criteria by which to judge the process has led to the conclusions that overly conservative controls, based on theory rather than practice, is in fact hampering the advancement of recycling technology. It is suggested that, where human ingestion is not planned, projects be initiated in which best practical (economically feasible) technology be utilized to recycle wastewater and that water quality be closely monitored and its actual impact on the end use be evaluated.

This paper discusses the Redux program to date and provides test data on the recycled water.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Quaternary Ammonium Resins as Water Disinfectants

AUTHORS: Gilbert E. Janauer and Ilona H. Walfish

AFFILIATION: State University of New York at Binghamton

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

The broad spectrum biocidal activity of water soluble compounds having long chain aliphatic quaternary ammonium functions (QUATs) is well known and is being utilitzed for the sterilization of hospital equipment among other applications. It was suggested (L. K. Wang and G. G. Perry, Water Res. Bull., 11, 919) that QUAT type compounds might be directly dissolved for drinking water disinfection on account of their low toxicity for mammals, although other alternatives to chlorination seem to be more promising.

A project was initiated at SUNY-Binghamton in 1976 based on the assumption that QUATs would still retain their biocidal properties with their quaternary ammonium functions firmly attached to a polymer matrix. Several different "QUAT resins" were prepared and tested by a team of students with support from an NSF-SOS grant in 1977. The preliminary study definitely proved the general validity of the approach and showed in particular, that a polystyrene type matrix containing the N,N-dimethyl-n-dodecylbenzyl ammonium group is indeed a strong contact bactericide. Since then, a number of batches of "QUAT 12" resin have been prepared, and the kill capacity for E. coli and B. subtilis has been determined. As many as 10^9 cells were killed in volumes of 100 to 2000 ml of solutions (containing either type of model organism) when applied to 1-2 ml beds of QUAT 12 at flow rates of up to 10 ml/min. QUAT 12 is synthesized from crosslinked, chloromethylated polystyrene in a procedure closely resembling the preparation of conventional strong base anion exchange resins (which do not exhibit any biocidal activity).

The proposed process would disinfect contaminated water by simply passing it through a bed of QUAT 12 (or similar preparation) in an operation resembling industrial water softening and demineralization by means of ion exchange materials. QUAT 12 is, of course, itself a specialty ion exchange resin, but it's biocidal properties are associated with the polymer-attached quaternary ammonium functions rather than with exchangeable counterions. It is a major advantage of this appraoch that existing ion exchange technology--ranging from large industrial to small scale household ion exchange purification--could be easily adapted. It is expected that QUAT 12 also acts as a potent virucide, fungicide, and sporicide in analogy to soluble QUAT 12 species. While the results of this work indicate promise for primary disinfection in small water systems, the new approach may prove even more valuable for final disinfection before the discharge (eventual potable reuse) of wastewater. Toxic compounds are neither added nor produced during the passage of water through QUAT 12 beds.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Recycling System for Mechanical Platers

AUTHORS: 1) Roy A. Ackerman, 2) Sam C. Crosby, & 3) R. E. Ellingwood

AFFILIATION: 1 & 2) ASTRE, 3) Soft Water Service Co.

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

One of the most stringent discharge requirements are those developed for plating systems.

ASTRE and the Soft Water Service Company were retained by a mechanical plating facility to help it comply with state and federal pretreatment discharge regulations. Since this plating facility currently employs ten people and has a small effluent flow rate, it would be fairly simple to comply with the proposed federal regulations. These deal only with cyanide, chromate, lead and cadmium, but the state authority wanted additional pH controls and flow equalization. However, upon further examination, it was quickly realized that reuse/recycle would be the most economical alternative.

The facility consists of a degrasing/descaling unit and a propriety mechanical (zinc and chrome) plating unit. The wastewater volume is very small--some 300 to 400 gallons per cycle. However, water discharge is sporadic, and the wastewater contents are highly variable. There are no cyanides, lead, or cadmium concentrations, but zinc, iron and chrome levels are high. The treatment process would obviously be specific for this device. Therefore, to lessen the capital flow required to complete the project, it was designed to be installed in stages.

The first stage involved wastewater segregation, installation of a pH control system, a chrome reduction unit, and effluent flow equalization. The next stage included sedimentation, filtration, and chrome recovery with water recycle. The devices used in the first stage were chosen to insure their continued applicability in the recycle/recovery stage, thereby reducing the costs of the overall system. It is expected that the water will be reused 40 times prior to discharge (to the POTW), reducing the water demand from 2400 gpd to 300 gallons/week.

Obviously, then, with a total installation cost of less than $15,000 and maximum annual operating costs of $750 (no credit given for chrome recovery), treating and recycling plating wastewater may not have to be an undue burden for plating facilities.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Trace Element Analysis of Several AWT Plant Effluents

AUTHORS: Herbert R. Pahren and Nancy S. Ulmer

AFFILIATION: U.S. E.P.A. - H.E.R.L.

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

Advanced wastewater treatment processes will undoubtedly be used in any system designed to produce potable water from wastewater. Generally, laboratory analyses to determine quality of the inorganics in the effluent are limited to a few common metals listed in the National Interim Primary Drinking Water Regulations.

A new multi-element procedure, which uses the principal of proton-induced x-ray emmissions was utilized to examine the effluents of four advanced wastewater treatment plants for 80 elements. The objective of this screening was to determine if any element which is not ordinarily checked might be present in the effluent at a level which would be of a health concern if the water was ever reused for potable purposes. At one plant, influent samples were obtained as well as effluent so that removals could be checked.

Results indicated that trace elements were not a problem at the advanced wastewater treatment plants. Values were consistently very low or below detection limits. The limited data on element removals showed some reductions to be high while others were low. Certain elements increased during the treatment process.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Reclaimed Water in the Marketplace

AUTHORS: Harvey O. Banks

AFFILIATION: Camp, Dresser & McKee, Inc.

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

Experience has amply demonstrated that water reclaimed through treatment of municipal waste waters has been successfully used for a variety of purposes--irrigation of certain crops, greenbelts, parks and golf courses, industrial cooling, some industrial processes, ground water recharge, recreational water bodies, for example. The marketability, or value, of reclaimed water is, however, site-specific. The relative value of reclaimed water to a particular user for a specific use, as compared to fresh water supplies, is dependent not only on the cost of producing or purchasing the reclaimed water but also on any internal costs involved in its use. The quality of reclaimed water will be lower than that of fresh water in most cases unless a very high degree of treatment is applied including demineralization which adds significantly to the cost and energy requirements. Each potential use will have limiting quality requirements which may be site-specific. For irrigation, greater quantities of reclaimed water must be applied as compared to fresh water to provide adequate leaching. The return flows may contribute additional polluting materials to the receiving waters. For industrial uses, additional internal treatment, dual piping systems or process changes may be required to enable use of reclaimed water, and the cost of final treatment and disposal of the industrial waste water may be greater than with use of fresh water. For ground water recharge, protection of the ground water quality is of paramount importance. This too is site-specific, particularly as regards any additional improvement in quality that may be provided by passage through the surficial materials. Institutional considerations, including rights to the reclaimed water and effects of diversion to other uses on present uses of the municipal effluent, may be important. The costs of storage, transport and distribution of the reclaimed water to diverse locations of potential uses as is generally the case in urban areas, are significant economic factors. The price that can be charged for reclaimed water may be significantly less than for fresh water because of poorer quality. A thorough market analysis is generally essential to determination of the feasibility of reclamation and reuse of municipal waste waters, particularly where diverse users or uses may be involved.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Water Reuse - Not only a Necessity but Profitable as Well

AUTHORS: John R. Snell and Sachiho Naito

AFFILIATION: Snell Environmental Group, Environmental Sanitation Engineers, Tokyo

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

The project described in the poster involves the supply of potable water, the treatment of wastewater, and recycling of half of the wastewater for what was to be a 6,500 room hotel complex--plus three villages with approximately 20,000 people--on the Isle of Bali, Indonesia, the famous resort area. Hydrological studies done by others proved to be over optimistic on water availability by a factor of 4 to 1. In order to make the project viable, our recommendation was made to cut the size of the hotel complex in half and to recycle about 55% of the wastewater after thorough treatment for many non-potable uses including: make up cooling water for air conditioning and refrigeration, washdown water and irrigation, and the central laundry. Water is supplied by wells from a lime stone aquifer consisting of 20 to 30 foot lenses of freshwater over salt water. Lime soda softening of the water was necessary prior to use. Freshwater from the complex was treated through approximately 30 acres of lagoons on a diked formerly brackish tidal water area. This raw water entered the first of a series of four ponds and moved through each pond successively over a period of four to six months. Each pond was designed not only to raise fish, but to have them harvested commercially. Effluent from the pond was generally removed through a perforated sand-covered interceptor pipe on the land side of the lagoon where some ground water was also intercepted. However, some water could be taken in directly from No. 4 pond if needed. This effluent was then passed through a multi media pressure filter, chlorinated, dechlorinated and used. Engineer's figures show that even without the offsetting profit from the harvested fish, cost of filtration and chlorination was less expensive than the cost of the initial wells, pumping through the transmission lines, plus the cost of softening.

Although the cycled water was considered clean enough and safe to drink, its use was limited to only non-potable purposes for civic and public relations reasons.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: An Overview of Industrial Wastewater Recycle/Reuse Practices

AUTHORS: 1) Ronald J. Turner, 2) E. F. Abrams, 3) E. F. Rissmann & 4) Chia-Soon Ku

AFFILIATION: 1) U.S.E.P.A. - I.E.R.L., 2 & 3) Versar, Inc.

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

National needs and regulatory pressures have made the water reuse concept increasingly more attractive to industry in recent years. The available literature and other sources of information were searched to determine what industry is doing to demonstrate the recycle and reuse of process wastewaters. Case histories involving both conventional and novel technologies were documented in this study conducted for the US EPA's Industrial Pollution Control Division, Industrial Environmental Research Laboratory - Cincinnati.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: The Tahoe-Truckee Sanitation Agency AWT Plant First Year in Perspective

AUTHORS: 1) Stanley A. Smith, 2) R. L. Chapman, & 3) O. R. Butterfield

AFFILIATION: 1 & 2) CH$_2$M-Hill Engineers & 3) Tahoe-Truckee Sanitation Agency

DATE OF SESSION: Wednesday, March 28 *SESSION NO:* Poster

Construction of the 4.8 mgd AWT plant of the Tahoe-Truckee Sanitation Agency is now essentially complete and the plant has been in operation for nearly a year. This plant features seven stages of treatment utilized to produce an effluent of exceptional quality. The effluent is subsequently discharged to a 25-acre subsurface disposal field from which it slowly percolates to the Truckee River about 30 miles above Reno, Nevada.

This paper presents an overview of the plant's features, construction costs, operation and maintenance costs, and performance.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Evaluation of Two Wastewater Alternatives in Simulation

AUTHORS: Larry D. Brown, Dan A. Brock and Sam A. Gray

AFFILIATION: Dallas Water Utilities

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

Two City of Dallas Purification plants, located on the Elm Fork of the Trinity River north of Dallas, are supplied by water released into the natural stream channel from two upstream reservoirs. The Trinity River below Dallas is an effluent dominated stream receiving treated municipal wastewater from Dallas, Ft. Worth, and other area cities. A possible supplement to the water supply for the area would be to pump water from the Trinity below Dallas up to the Elm Fork of the Trinity above the purification plants.

A river quantity/quality model developed by Dallas Water Utilities under a grant from the Office of Water Research and Technology is being used to study the effects of water recycling on the quality of river water. In one simulation problem, all wastewater plants contributing to the river flow were assumed to be upgraded to a 10-10-5 level of treatment (10 mg/l biochemical oxygen demand, 10 mg/l total suspended solids, and 5 mg/l ammonia nitrogen concentration). Climatological conditions were taken from a typical low flow summer period. A withdrawal of 188 cfs was taken from the Trinity approximately 3 miles downstream from the Dallas Central Wastewater Treatment plant. This water was pumped to a point just downstream from Lake Lewisville, the major Elm Fork supply reservoir. This particular flow constitutes slightly more than half of the normal demand released from Elm Fork reservoirs during dry summer conditions.

The resulting simulation predicted phytoplankton growth concentrations of 40 to 80 micrograms chlorophyll "a" per liter near purification plant intakes. Depending on the type of algae present, and other factors, water of this quality would probably have unpleasant tastes and odors that would be difficult to remove during purification.

The simulation results imply that recycling this amount of water would not be practical during summer low flow conditions. However, further study is needed to determine the practicality of recycling other rates, at other seasons of the year, particularly during winter months. Further analysis should include enumeration and identification of algae in the water released from Lake Lewisville to determine when problems species would likely be present.

Lake Ray Hubbard is operated by the City of Dallas for municipal water supply. The City of Garland operates a nearby wastewater treatment plant which has been upgraded to achieve a 10 mg/l biochemical oxygen demand a 10 mg/l total suspended solids effluent. Associated with this level of treatment was total nitrogen at 17.5 mg/l and total phosphorus at 2 mg/l. A lake water quality model derived from LAKE I (EPA-660/3-75-0005) was used to simulate the effect on lake phytoplankton concentrations of injecting treated effluent from the Garland plant into Lake Ray Hubbard. The LAKE I model had previously been calibrated to Lake Hubbard for a fifteen month period of sampling activity (May 1976 to August 1977).

The model as applied by the City of Dallas assumes the lake divided into two vertical strata, with complete mixing of nutrients and plankton within each strata.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Regeneration of Wastewater for Reuse Through HYDROPERM Microfiltration

AUTHORS: John E. Santo and Norman I. Shapira

AFFILIATION: Hydronautics, Inc.

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

The present paper describes the results of three separate studies of treatment of wastewaters for reuse by employing a unique tubular microfiltration system, called Hydroperm. The filtration is accomplished at relatively low pressures (~5 psi) by utilizing internal circulation through rugged, thick-walled porous plastic tubes. Because of the controllable microporosity of the tubes and the in-depth nature of the filtration process, the tubes are able to produce a reusable permeate in most cases, either by themselves or with minimal further treatment (such as chlorination or ozonation).

The three applications discussed in the present paper are: (i) the treatment of waste from the U. S. Army's "MUST" hospital complex; (ii) the treatment of "pink water" wastes that are generated during LAP (Load, Assembly and Pack) operations at Army Ammunition Plants; and (iii) the treatment of waste from commercial laundries. The paper describes, for each of the three problems just mentioned, results of laboratory tests with the actual effluents as well as the technical and economic factors influencing full-scale operation. Where applicable, results on pilot-scale or in-situ operations are also given, as are comparisons with ultrafiltration systems.

Results are also presented in the paper on Hydroperm filtration of the wash water wastes from commercial laundries. Tests demonstrate that high flux levels (≈40 gallons/ft^2-day) are obtained for even those wastewaters which contain significant amounts (several thousand ppm) of oil and grease, as well as total solids as high as 40,000 ppm. Continuous operation for nearly seven hundred hours at 70°C confirms the ruggedness of the filtration tubes and their ability to perform well under unfavorable conditions. Comparisons are made with available data on ultrafiltration of laundry wastewaters.

Other applications of the Hydroperm process are also briefly discussed in the paper, including a 24,000 gallon-per-day, field demonstration system, which is being developed under the support of the U. S. Environmental Protection Agency, for the removal of toxic-heavy metals from battery manufacturing wastewaters.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: A Domestic Wastewater Recycling System

AUTHORS: Robert O. Mankes

AFFILIATION: Pure Cycle Corporation

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

Pure Cycle Corporation, a Boulder, Colorado firm, has designed and developed a system for recycling residential water supplies. The unit produces water for all household needs, including drinking and cooking, from household sewage and wastewater. It is an on-site water and sewage treatment plant which in effect eliminates the need for private well/septic systems or centralized municipal water/sewer service.

The Water Recycling System is controlled and monitored by a microprocessor, which eliminates the need for frequent human intervention with the System. Reporting to the microprocessor are a series of sensors and transducers including level, total dissolved solids (conductivity), turbidity (nephelometer), sterilization (radiation intensity), total organics (ultraviolet adsorption).

All household sewage is treated in a series of five steps, including: biological oxidation through anerobic and aerobic digestion, in which the organics are oxidized. Following biological oxidation the sample is filtered via an ultrafilter having a molecular weight cut-off of approximately 50,000. Following ultrafiltration, the water sample passes through an organic adsorber to remove the remaining trace organics which have not been removed by ultrafiltration or bio-digestion. The organic adsorbant preferentially removes hydrophobic organics. The polar organics not removed by this stage are removed by the weak-base ionic exchange resin in the following stage. In the fourth phase of treatment the water passes through a series of exchange beds. These remove the polar organics, color and most all inorganic salts. The demineralization system incorporates an automatic regeneration system which on demand manufactures acid and base for regenerating the ion exchange beds. Following demineralization, the sample passes through an ultraviolet sterilizer. The ultraviolet sterilization unit has been sized to achieve 100% kill of all bacteria for which there is data, including pathogens. After all the water has been sterilized it is sent on to a potable water storage cistern and pressurized for delivery back into the household.

The sensors reporting to the microprocessor are continuous and on-line sensors. When they indicate a malfunction at any one of the stages the microprocessor initiates a correction and recovery procedure. If the problem is not corrected within a specified time, the microprocessor halts the processing of water and communicates the problem via ordinary telephone lines to a central service center for corrective action.

The Water System has been designed to produce water having no more than 12 ppm NaCL.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Legal Innovations to Promote Planned Reuse of Water in the Appropriation-Doctrine States of the American Southwest

AUTHORS: Anthony S. Trumbly

AFFILIATION: Denver Research Institute

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

The American Southwest suffers from inadequate water resources in terms of quantity. The problem is exacerbated by natural and man-made quality degradations which reduce the usefulness of existing resources. All competing water users cannot be satisfied even though water is customarily used by a succession of users as it flows downstream. Planned reuse will supplement this natural successive use through both increased use of existing resources and disposition of low-quality waters in consumptive applications.

This paper first sets out the fundamental patterns of control on water use in the Southwestern appropriation-doctrine states, particularly those within the Colorado River Basin. These patterns include: international treaties and interstate compacts allocating the rights and duties of governmental entities regarding the waters of the river; federal reclamation projects, and the regulations and contracts governing distribution of the water from such projects; federal and Indian rights to water under the implied-reservation doctrine; and the water allocation processes of the individual basin states.

Barriers to reuse are then examined, using several examples of potential reuse options as models for discussion of the legal constraints involved. The barriers are organized according to the source of the barrier, i.e., whether it stems from the level of federal-interstate relations or from intrastate legal circumstances. Finally, methods for alleviating barriers to reuse or accomodating reuse more easily within the existing water allocation system are identified and evaluated for their potential degree of success and collateral effects on the allocation system as a whole.

The paper shows that there are few direct legal prohibitions on reuse, although there are some restrictions on the type of reuse permissible for certain sources of water. The legal constraints on reuse result more commonly from unintentional or unavoidable characteristics of the appropriation doctrine of water allocation.

The solutions to reuse-inhibiting legal situations vary widely in their potential contribution to the goal of increased water utilization. This paper considers strategies for encouraging reuse in the context of existing water allocations. Particularly where water supplies are completely allocated, the benefits to be derived from reuse must be compared with the value of existing uses and the damage done by the "ripple effects" of any changes made. Recognition of the interrelatedness of the elements of the allocation system is of prime importance in understanding the potential role of reuse in the states of the Southwest.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Educational and Social Factors Effecting Public Acceptance of Reclaimed Water

AUTHORS: Betty H. Olson, Jeffrey A. Henning, Richard Marschack & Martin Rigby

AFFILIATION: University of California - Irvine

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

The importance of reclaimed water to augment current water supplies is fast receiving nationwide attention. Those states particularly interested in reclamation projects are highly populated and have restricted available water resources. Already, California has developed several vigorous plans to utilize purified wastewater to augment domestic supplies. These implemented projects are restricted to secondary contact. The success and the further development of these projects depend not only on the safety of the renovated wastewater, but also on the ability of the public to accept this alternative source. Previous work concerning public acceptance of wastewater has demonstrated that the public is willing to accept secondary contact uses of reclaimed water. However, there is still great resistance to the acceptance of renovated wastewater for primary contact purposes beyond recreation. Bruvold (1975) has hypothesized that as the use of reclaimed water approaches reality increased negative attitudes develop.

The present investigation was undertaken to determine what factors affected public acceptance of renovated wastewater. A total of 1,000 individuals were sampled. 500 Individuals were selected at random from Irvine, California, a community which is actively involved in water reclamation projects, and 500 individuals from Anaheim, California, a community with no reclamation projects.

Higher levels of education result in more favorable attitudes toward reclaimed water in males, but not in females (Olson and Pratte, 1977). The present investigation evaluated different educational backgrounds of men and women to determine if this was the reason for different acceptance patterns.

The results of the study indicated that economics is a strong determining factor in public acceptance of reclaimed water. Further, knowledge concerning both domestic and reclamation practices was minimal. The majority of respondents knew that reclamation practices were minimal. The majority of respondents knew that reclamation projects existed throughout the state, but could not identify the location of these projects. This was true even when the projects were located in their community.

The results of this study indicate that the recent drought that California experienced had little effect on peoples' attitudes toward reclaimed water. Here it is important to emphasize that this study was conducted in Southern California which was less severely affected than Northern California. Therefore, the effect of the drought would undoubtedly be more pronounced in the Northern part of the State. The study revealed that the most important and effective way to oreintate favorable attitudes toward renovated water is through educational processes, preferably using mass media such as television or radio to familiarize individuals with the potential benefits and possible risks from expanded uses of wastewater.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25–30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Use of Reclaimed Wastewater to Operate a Seawater Intrusion Control Barrier

AUTHORS: 1) Jerome J. Wedding, 2) Michael A. Fong, and 3) Colleen M. Crafts

AFFILIATION: 1) Ventura Regional County Sanitation District, 2&3) PRC Toups Corp.

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

The use of reclaimed wastewater to create a seawater intrusion barrier is being evaluated by the Ventura Regional County Sanitation District (in California) and PRC Toups Corporati Increasing water demands within and subsequent overdrafting of the Oxnard Plain Costal Aquifer has resulted in seawater intrusion along Ventura County's coastal boundry. PRC Toups Corporation is evaluating the technical, institutional, and economic feasibility of injecting reclaimed wastewater to prevent further intrusion and mineralization of water supplies.

To produce a reclaimed water of suitable quality for injection, various advanced process combinations are being developed and tested, including the following:

1. Multimedia filtration followed by ozonation;
2. Multimedia filtration, reverse osmosis and chlorination;
3. Chlorination, diatomaceous earth filtration and ozonation;
4. Coagulation, multimedia filtration, reverse osmosis and chlorination.

To determine the capability of these processes to meet a quality requirements for injection, as well as public health regulations a pilot program is being developed from the results of this investigation. At the request of state regulatory agencies, development of injection water standards and adequate treatment process combinations in conformance with current federal underground injection control programs are integral components of this investigation.

Issues to be addressed include the impact of stable organics and viruses present in the reclaimed water on the native groundwaters, reverse osmosis product water yield, and specific in removal by the reverse osmosis process. Cost-effectiveness criteria for the desalination process will also be developed with respect to uses and quality requirements.

This study will provide solutions to water supply and quality problems due to seawater intrusion within Ventura County. The District's program is expected to have a significant impact on seawater intrusion and groundwater overdraft in the groundwater basin and to decrease problems of mineralization caused by seawater intrusion, recycling of irrigation waters and addition of salts in the form of fertilizers. On a broader scale, data and conclusions from this study will provide a data baseline for future studies on wastewater reuse for well injection and for creation of hydraulic barriers.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Reductive Degradation Treatment of Industrial and Municipal Wastewaters

AUTHORS: Keith H. Sweeny

AFFILIATION: Envirogenics Systems Company

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

Reductive degradation represents a new and novel approach to the renovation of toxicant-laden waters. Water reuse in manufacturing or processing plant recycle, ground water recharge, or safe discharge into rivers and waters are feasible with this treatment.

Reductive degradation is a simple process, involving the use of a catalyzed metal powder to chemically degrade the pollutant in an ambient temperature reaction. The process appears to be mainly that of dechlorination, although, hydroxylation, saturation or aromatic structures, ring cleavage and hydrolysis have been found to occur, producing species of reduced toxicity.

Contact between the wastewater to be treated and the reductant powder is achieved by flowing through a bed of the reductant powder mixed with an inert diluent such as sand, to give requisite retention and flow properties, or better by fluidizing the catalyzed metal powder in a stream of the wastewater. Flow rates as high as 22 gallons per minute per square foot of column have been employed.

The process is highly effective for a wide variety of toxicants. A large number of chlorinated hydrocarbon pesticides have been found reducible, as well as related industrial compounds. Chloroform and related THMs appear to be readily degraded. Non-chlorinated toxicants such as nitrophenol and the carcinogen dimethylnitrosamine have been reductively decomposed. The degradation of the dissolved toxicant in water has usually produced effluent with the toxicant less than one microgram per liter in the effluent and often not detected by electron-capture detection gas chromatography.

The simplicity of the reductive degradation process results in low projected operating and capital costs. The process may involve no more than a pump, flow controls and the reductant bed, for a fluidized bed system operating with a near-neutral stream.

Waters more acid than 6.5 or more alkaline than pH~7.5 require neutralization. Filtration would be required if the sand-diluted reductant bed is employed. A small amount of reductant metal ion, generally ferrous iron in the range 1 to 5 milligrams per liter, is present in the effluent and may be removed by standard flocculation techniques.

Reductive treatment costs were estimated from \$0.138/1000 gal at 1 MGD to \$0.064/1000 gal at 50 MGD for a single pass through the reductor bed and \$0.210 to \$0.120 for a more conservative double-pass through the bed, compared to \$1.84 to \$0.40/1000 gal for the activated carbon treatment. These costs include operating costs and amortized capital investment. The capital investment for the reductive degradation system is significantly less than the activated carbon, a 10 MGD single pass reductive unit having an estimated cost of \$352,000 and \$643,000 for a double-pass unit, while the activated carbon unit is estimated to cost \$12,667,000 -- 20-to 36-fold more.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: A Water Reuse Program on St. Croix, Virgin Islands

AUTHORS: O. K. Buros

AFFILIATION: CH$_2$M-Hill Engineers

DATE OF SESSION: Thursday, March 29 SESSION NO: Poster

The soils, geology, and climatic conditions in the U.S. Virgin Islands restrict the amount of water available for water supply purposes. With increased population and standard of living, the use of water has exceeded the available supply during the past decade. Since 1968, the deficit has been made up by desalinating seawater. This cost of this supplemental water ranges from \$1.05 to \$5.25/m^3 (\$4-\$20/k gal).

On the largest island, St. Croix, a program of wastewater reclamation and reuse was begun by the government in 1971. The program began with the construction and operation of a wastewater reclamation facility with a design capacity of 1,900 m^3/day (0.5 mgd). The reclaimed water was used primarily for recharge to augment the ground water and to reduce seawater intrusion. Other uses, such as agricultural irrigation, pisciculture and mariculture, were explored.

From 1971 through 1975, the facility was operated under the direction of a consultant, CH2M HILL. Since 1975, the Government of the U.S. Virgin Islands has directed the program. Plans are now underway to increase the amount of water reclaimed to allow additional uses of this valuable resource.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Virus Removal from Sewage During High Rate Land Filtration

AUTHORS: Charles P. Gerba and J. C. Lance

AFFILIATION: Baylor College of Medicine, U.S.D.A. - Water Conservation Lab

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

Land Treatment of sewage water by filtering it through the soil to recharge the groundwater table shows promise as an economical way to purify sewage water for reuse. However, land treatment systems must be carefully planned and managed to prevent groundwater contamination. For example, sewage contains many intestinal viruses which must be removed as the water moves through the soil. Research with soil columns which have been shown to be good models of a field groundwater recharge system showed that most polioviruses are held near the soil surface. Secondary sewage effluent, seeded with about 3 x 10^4 PPU/ml poliovirus type 1 (LSc), was filtered through 250 cm columns packed with calcareous sand from an area in the Salt River bed used for groundwater recharging of secondary sewage effluent. Most of the viruses were adsorbed in the top 5 cm of soil. Flooding a column continuously for 27 days with the sewage-water virus mixture did not saturate the top few centimeters of soil with viruses or affect virus movement. Flooding columns with deionized water caused virus desorption from the soil, but adding $CaCl_2$ to the deionized water or draining the soil between flooding with the sewage water virus mixture and flooding with deionized water prevented desorption. Virus removal from primary sewage effluent followed a similar pattern.

When the concentration of poliovirus added to the sewage water was varied from 0.9 x 10^2 x 10^4 PFU/ml the number of viruses detected at each soil depth increased as the concentration of added virus increased. However, the percentage of added viruses remaining at each depth was about the same for each concentration.

Increasing the flow rate through the columns from 0.15 to 0.6 m/day did not affect poliovirus movement. Increasing the flow rate to 1.2 m/day caused a virus break through. However, more than 99% of the viruses were removed at flow rates up to 12 m/day.

This sand also adsorbed other intestinal viruses called Echo viruses but not as many were held near the soil surface. However, adsorption of Echo virus in the top 80 cm of soil is the same as for poliovirus. The adsorption patterns for Echo type 29 and polio type 1 were similar with 90% adsorption in the top 2 cm and 99.99% adsorption for the 250-cm column. Adsorption of Echo type 1 was 77% for the top 2 cm and 99.99% for the 250-cm column. Most of the differences in adsorption patterns occurred in the top 40 cm of soil.

Thus, viruses applied in sewage effluent would not be expected to move through 250 cm of calcareous sand, like that used in our laboratory columns, if flooding and drying cycles are carefully managed. Future research will concentrate on virus adsorption by different soils.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25—30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Born Free Almost

AUTHORS: Lawrence Hirsch

AFFILIATION: Hirsch & Company, Consultants

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

When the 1,800 acre Wild Animal Park opened in 1972 just south of Escondido, California, in San Diego County, some called it a second Kenya. The San Pasqual valley where the park is located, has scarce rainfall, temperatures and high veldt (grassland with scattered shrubs and trees) on land which rises from 400 to 1,400 feet - all of which are typical of East Africa. The park's unusual canyon topography allows public viewing of the animals from a five-mile electric monorail system.

To the visitor it seems a perfect site for such a park. But there was this problem with water. There wasn't any - or certainly not enough to support over 3,000 animals of 226 different species .. animals such as lions, tigers, great apes, monkeys, colorful birds, rodents, hoofed stock and reptiles.

Water is a precious commodity in San Pasqual Valley, where the precipitation in the four or five rainy months averages seven inches. This does not maintain stock watering holes, the landscape irrigation needs or water for visitors, which totaled 1.1 million in 1977.

Geological water studies concluded that onsite water drilling would yield the barest minimum water supply. Our cost analyses led to the adoption of a two-stage plan to construct a 0.5 million gallon steel storage reservoir and a 16-inch, two-mile offsite transmission main to the Escondido Mutual Water Company, operated by the City of Escondido.

There is an interconnection to the Colorado River water supply through systems operated b the Metropolitan Water District of Southern California and the San Diego County Water Authority. Water costs led to a detailed plan to reclaim and reuse water from the sewage treatment plant.

These plans were carefully reviewed by zoo veterinarians, the city utilities engineering department, the San Diego Regional Water Quality Control Board, the county and state Health Departments and the State Water Resources Department.

One purpose of the park is to influence public opinion to encourage legislation leading to establishment of meaningful internationally accepted rules and regulations dealing with animal procurement and exhibition. Conservation of natural resources, both plants and animals, is of prime concern. Over 40 animals have become extinct since the turn of the century and presently there are over 1,000 species of birds, mammals and reptiles on the endangered list. At the present rate, 25 more animals will become extinct in the next 10 years.

The park will provide studies in bahavioral attitudes, breeding practices and group interaction that may supplement and relieve present animal resources. This preserve offers people of all ages an opportunity to view and enjoy some of the magnificent animals of the world in their natural surroundings.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Amarillo's Water Supply = 70% New + 30% Reused

AUTHORS: Clarence H. Scherer

AFFILIATION: City of Amarillo, Texas

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

This will be a poster project showing the overall water picture for the City of Amarillo and the part that our use of wastewater effluent plays in it. The City of Amarillo has been successfully reclaiming wastewater and selling it to industrial customers for non-potable use since 1954. A major power company is currently purchasing almost all of the effluent produced at the city's 12 MGD River Road Plant and will in the near future be using most of the effluent from the newly expanded 9 MGD Hollywood Road Plant when that project is completed. At that time, some 30% of the City of Amarillo's total water supply will be made up of reclaimed wastewater effluent, or "reused water". The balance of the city's water needs are taken from diminishing underground water sources and from a surface lake.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Behavior of Volatile and Extractable Organics in a Combined Biological/PCT of a Municipal Wastewater

AUTHORS: Thomas A. Pressley

AFFILIATION: U.S.E.P.A. - M.E.R.L.

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

The purpose of this study was to examine qualitatively and semi-quantitatively the volatile (purgeable) organics and the lesser volatile liquid/liquid extractable organics present after the major steps of a reuse treatment system. Conventional GC and GC/MS methods were employed.

The combined biological/physical-chemical treatment reuse system at the EPA-DC Pilot Plant consisted of a screening device to remove coarse material, lime clarification (pH 10.5), dispersed growth nitrification, fixed film denitrification, carbon adsorption, dual media filtration, and chlorination for disinfection. This sequence of processes was chosen because they form a treatment system capable of producing a high quality water from municipal raw wastewater. Typically, effluent TOC values averaged 2 ml/l.

The final and intermediate effluents were examined for trihalomethanes and other highly volatile organics and for organics extractable by methylene chloride. Trihalomethanes and other purgeable organics typically totalled 40 μg/l in the raw wastewater. A sharp decrease in concentration occurred following lime clarification and nitrification. Chloroform levels were reduced by 70 percent and the other trihalomethanes by 90 percent or better.

Further significant reduction in purgeable organics did not occur in the treatment train. The trihalomethanes, after final chlorination to a free chlorine residual of approximately 2.5 mg/l, exhibited a sharp increase to typical values of 25 μg/l. Because of the low trihalomethane concentrations after chlorination, it was concluded that removal of the soluble humus material by the system reduced the formation of trihalomethanes in the effluent.

The lesser volatile liquid/liquid extractable organics identified in the raw wastewater influent were generally reduced by the reuse system to levels not detectable by the apparatus employed in these tests.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Soda Ash Treatment of Acid Mine Drainage Impregnated Streams for Potable Reuse

AUTHORS: 1) David A. Long, 2) James L. Butler, and 3) Michael J. Lenkevich

AFFILIATION: 1) Penn State University, 2&3) Dobson and Foreman, Inc.

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

Utilization of acid mine drainage impregnated streams as a source of potable and industrial water has become a major goal of several proposed mine acid drainage treatment schemes. From among the various schemes available, the lime neutralization - soda ash softening process was selected for use and study at Altoona, Pennsylvania.

The treatment plant, as constructed, has the capability of treating waters from Kittanning Run (acid mine polluted) alone or in combination with waters from other city sources to achieve: 1) neutralization and iron removal to levels satisfactory for stream release, 2) softening to approximately 100 mg/ℓ $CaCo_3$ hardness for municipal use and 3) softening to a hardness of 200 mg/ℓ $CaCO_3$ or higher to meet industrial use requirements.

It was the objective of the reported study to evaluate the technical and economic feasibility of softening neutralized mine acid drainage impregnated waters by means of the cold lime - soda ash process. The study was conducted at full plant scale utilizing the Altoona Treatment Plant located near the Horseshoe Curve area of Altoona, Pennsylvania. Unit processes employed at the plant consist of lime neutralization, aeration, settling, soda ash softening, recarbonation and filtration. The study was conducted over a five month period (August 1974 - December 1974) and generally indicated the desired effluent quality can be achieved.

A basic requirement of the study method utilized was that a relatively constant hydraulic (3.5 mgd) and mineral loading should be applied to the treatment process. This requirement could be controlled using Kittanning Run exclusively or by blending the total flow in Kittanning Run with constant quality Impounding Dam water, a fairly successful procedure so long as the flow in Kittanning Run did not exceed the maximum 3.5 mgd. Temperature, however, was a parameter which could not be controlled.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Nitrogen Removed in a Modified Subsurface Sewage Disposal System

AUTHORS: 1) Robert C. Forgione, 2) N. Bartilucci, 3) A. Andreole & 4) R. Reyno

AFFILIATION: 1&2) Dvirka & Bartilucci Consults 3&4) Suffolk County Dept. of Health

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

Contamination of groundwater by nitrates from individual septic tank leaching systems is a potentially serious public health problem in Suffolk County, where groundwater is the sole water supply source for its 1,300,000 inhabitants. This study investigated the possiblity of developing a system for eliminating nitrate-nitrogen from wastewater which would otherwise leach through the soil and contaminate the groundwater.

A conventional septic tank - leaching field residential subsurface sewage disposal system was constructed. A pan-shaped impervious membrane was installed in the soil below the leaching field to detain the leachate. Methanol, as a carbon source for denitrification, was injected into the pan.

After more than one year of operation, it was found that the system is capable of removing nitrate-nitrogen to well below the recommended public health limit. It is believed that with further system refinement a practical method of removing nitrate contanminants from groundwater due to individual subsurface disposal systems will be available.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Water Reuse and the Council of Pollution Control Financing Agencies

AUTHORS: James H. McCall

AFFILIATION: Council of Pollution Control Financing Agencies

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

The Council of Pollution Control Financing Agencies is comprised of state and local agencies which issue industrial pollution control revenue bonds, an important method of low-cost financing to help businesses comply with air, water quality, and waste disposal standards. Its associates include banks, investment, industrial and law firms who fund and facilitate these programs.

Among proposed Council-sponsored projects are:

a. Surveys of existing data sources for forecasts of pollution control financing needs;
b. Development of financing information programs for use by members for small businesses faced with compliance needs.
c. Encouragement of closer cooperation among federal departments and agencies to develop more effective criteria and regulations for pollution control financing.
d. Workshops and seminars to allow representatives of industry, government and finance to exchange views and ideas about pollution control financing.
e. Series of publications for use by the public.

The initial thrust of the Council has been to establish liaison with organizations with kindred interests, including the Association of Metropolitan Sewage Agencies; Public Securities Association; American Iron and Steel Institute, Edison Electric Institute; National Association of Manufacturers; Water Quality Council; Food Processors Water Conference; and the National Solid Waste Management Association.

A major pending issue of the Council is that current federal regulations prohibit low-cost financing of most industrial recycling or reuse projects. These investments must compete with the normal productive projects of an industry and the Council believes the policy deserves re-examination, particularly in view of recent legislation to create incentive for water supply projects.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Monitoring Organic Loading with the Electrochemical Organic Content (EOC) Analyzer

AUTHORS: Barry W. Peterman and R. J. Davenport

AFFILIATION: U.S.A. M. B. R. D. L., Life Systems, Inc.

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

A need exists in water quality monitoring and unit process control for on-line, continuous, automated and low cost instrumentation for monitoring organics in water. The Electrochemical Organic Content (EOC) Analyzer is one approach to satisfying this need. The EOC Analyzer uses a unique electrochemical method of monitoring organic impurities in water. It responds to the general organic content of water in much the same way that conductivity monitors respond to the general concentration of ions in water. Some ions produce a large conductivity response, while other ions at the same concentration produce a smaller response. The total conductivity for a sample containing a mixture of ions is therefore a general indicator of the water quality.

The EOC Analyzer is considered to be the organic analog of conductivity monitors. It operates by electrochemical adsorption of organics and measurement of the change in the capacitance at the electrode/solution interface. The response of the analyzer to specific organics is dependent upon the degree to which they adsorb on the indicating electrode. Organics which adsorb strongly produce a large response, while other organics that adsorb less produce a smaller response at the same concentration. Therefore, the total response to a mixture of organic solutes is a general indication of the organic content of the water.

Besides the general nature of its response, the EOC Analyzer is similar to conductivity monitors in other ways. The TOC Analyzer is simple to operate because it is highly automated. A goal of the development is automated, unattended operation for up to 30 days. The simplicity of the EOC measurement suggests that the EOC Analyzers ultimately will be low cost instruments and will be inexpensive to operate and maintain.

The EOC Analyzer has one feature which is unlike conductivity or other organic solute monitors. The operating parameters of the EOC Analyzer can be adjusted to result in selective response to certain groups of organic solutes. This is achieved by adjusting electrochemical parameters and the electrolyte used for the measurement. Using this approach, the EOC Analyzer may be useful in providing additional information about the composition of effluents and wastewaters. It also can be used to monitor organic contaminants that are special indicators of water quality or treatment efficiency.

A development version of the EOC Analyzer has been assembled for on-line process monitoring and control applications. This analyzer has been evaluated for monitoring shower and laundry wastewaters treated by reverse osmosis and other unit processes. Other tests have been performed to evaluate the analyzer in monitoring the quality of ozonated hospital wastewaters. This paper reports results of those tests and evaluations.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Coal Gasification Wastewater Reuse

AUTHORS: 1) Richard W. Walters, 2) Richard G. Luthy & 3) Gary F. Vajda

AFFILIATION: 1 & 2) Carnegie-Mellon University 3) Procon, Inc.

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

This paper will present results of on-going studies to evaluate water reuse criteria and treatment strategies in coal coking and in high BTU coal gasification. The approach to this problem consists of:

(a) Identifying minimum water quality criteria for solids and gas quenching, indirect cooling, and steam production,

(b) Evaluating laboratory scale water reuse systems, and

(c) Assessing economic incentive and treatment strategies to identify treatment trains worthy of more detailed study.

Experimental data will be presented on results of screening studies for coal gasification water reuse systems. These results will include evaluation of the following wastewater unit operations: phenol recovery, ammonia stripping, biological oxidation, carbon adsorption, ion exchange, and reverse osmosis.

Recommendations will be made relative to the effectiveness of various water reuse strategies. Deficiencies in the state of the art knowledge will also be discussed.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Accelerated Surface Water Eutrophication from Land Disposal of Sewage

AUTHORS: Martin J. J. Dayton and Agris Berzins

AFFILIATION: Dayton & Knight, Ltd., - Canada

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

During the last decade, land disposal of sewage has gained renewed popularity as a means of water reuse. In water short areas of high potential agricultural land in British Columbia, this appeared to be an excellent solution to a three fold problem:

(a) Surface water pollution and particularly eutrophication.

(b) Sewage disposal from growing municipalities.

(c) Agricultural production.

In the Okanagan Basin the theoretical flow-through time in the main lake, however, has increased from 40 years to 50 years as a result of water withdrawal and usage by evapotranspiration on agricultural lands. It is further projected that the lake flow-through time can increase to 100 years if further agricultural land is developed and all wastewater from growing municipalities is reused directly for agriculture.

There should now be concern that water reuse for agriculture may not be compatible with surface water quality protection in this area.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25-30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Ozone Applications: a Water Reuse Review

AUTHORS: Harvey M. Rosen

AFFILIATION: Union Carbide Corp. - Linde Division

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

The Conference theme, "Water Reuse--From Research to Application," is representative of the current position of ozone in water, wastewater and/or advanced wastewater treatment applications. Ozone is currently used municipally and industrially in full scale facilities for a number of applications, and is being studied for many more at the pilot scale and in the laboratory.

A review of ozone use as it might apply to reuse, which covers disinfection, direct oxidation to remove soluble organics, suspended solids, and specific micropollutants, will be presented. Removal of organics by flotation, microflocculation and stripping as adjuncts to direct oxidation will also be discussed. Other applications where ozone is combined with other treatment steps such as catalytic oxidation and pretreatment to enhance a following biological treatment step are also included.

Some of the new installations primarily but not exclusively in the U.S. will be listed, and a few will be discussed due to features that make them somewhat unique.

Ozone data from research to application will be displayed in segments of treatment from wastewater to potable water and some conclusions drawn about the future of ozone's place in reuse.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Reuse of Wastewater Containing Firefighting Agent

AUTHORS: D. B. Chan and Edward S. K. Chian

AFFILIATION: Naval Civil Engineering Lab, Georgia Institute of Technology

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

Firefighting training at Military bases consumes considerable amounts of water and a type of firefighting agent named Aqueous Film Forming Foam (AFFF). Generally a 6% (volume by volume, v/v) AFFF solution is used in firefighting. The AFFF consists of fluorocarbon su factant, ethylene glycol and its derivatives, and water. Although the constituents of AF are partially biodegradable, they impose toxicity effect (especially when concentration i over 100 ppm v/v) to conventional biological wastewater treatment process and to some aquatic/marine lives, such as oyster larvae. Long detention time and high dilution rate are currently being used as the only available treatment and disposal method of the firefighting wastewater. Unburned fuels and combustion by-product that are not removed in oi water separation process, provided in the pretreatment prior to its discharge to the sewer, further enhances the toxicity effect. Therefore, for economical, environmental, pollution abatement, and water conservation reasons, reclamation and reuse of both firefighting agent and the water have been considered as the most cost-effective method for disposing the firefighting wastewater.

A treatability study indicates that pretreatment of a 4% (v/v) AFFF containing wastewater by adding 300 mg/L alum can remove the AFFF concentration down to 1.5% (using MBAS as measuring parameter) together with other contaminants, fuels and combustion byproduct This pretreated effluent can then be reused for diluting the AFFF concentrate, or be diluted and sicharged to sewer for further treatment. An ultrafiltration followed by a rever osmosis using DuPont B-10 module operated at 600 psig. was experimented as an another treatment alternative. It was found that this method could cost-effectively purify and concentrate the AFFF to about 40% concentration range (from original 4% solution). Reclaimed AFFF and water can both be stored for reuse. This concentration practice may save about 2,000 gal/week of AFFF (@ $6/gal) and 100,000 gal/week of water (and equivalent amount of wastewater to be disposed of) (@ $1/1,000 gal combined cost) at a firefighting training school.

A solar aquacell consisting of an extended aeration lagoon and a water hyacinth pond was used as another alternative for treating the firefignting waste containing 0.2% (v/v) AFFF (after substantial sewage dilution). The results indicated this type of biological process has high application potential in terms of cost-effectiveness, and the possibility of reusing effluent water.

An Electrochemical Organic Content (EOC) Analyzer currently under development was tested for its applicability in monitoring AFF concentration in the wastewater and the pretreated effluent. An acidic electrolyte, a 0.1 M HCLO4 solution was found necessary for detecting the surfactant contained in the AFFF. A high sensitivity response to the AFFT concentration (using TOC as measuring parameter) in the range of 1.0 to 100 ppm v/v was obtained. It is possible to develop this EPC Analyzer for automated AFFF wastewater treatment process control and effluent quality monitoring.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Military Field Sanitation and Wastewater Reuse

AUTHORS: Charles E. Imel, D. B. Chan, and T. Kuepper

AFFILIATION: Naval Civil Engineering Lab

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

Statistics has shown that the field sanitation practices have significant impact to the success of military primary mission. Non-combat casulties resulting from personnel leaving shelter for sanitation reasons, and/or from diseases induced by poor physical hygiene and living environment sanitation would directly reduce the troop combat strength and readiness. Improved field head, shower, laundry, liquid and solid waste handling procedures are required for more sophisticated future military crisis control missions.

Water supply that can weaken combat logistic support and the waste generated that can deteriorate personnel hygiene and envirnomental sanitation must be confined to cause minimum impact to the deployed troop. Water, the primary field sanitation media is important to the successful operation of all field sanitation facilities/systems. Since water is generally im prime rate at military field environment, waste conservation, and wastewater reclamation for reuse must be practiced. These practices would result in minimizing the logistic burden for water importation, manpower waste for liquid waste disposal and enhance the applicability of field sanitation system.

Water conservation includes the use of water-saving shower head (Nova type) and low-water flush toilet. Wastewater treatment for recycling and reuse, currently under development include the reclamation of urine for toilet and urinal flushing. Urine purification processes investigated include ozonation, combination of ozonation and UV radiation, UV radiation, activated carbon adsorption, chemical treatment and electrolysis. Odor, color, turdibity, COD, TKN, and total coliform were used for process effectiveness evaluation. Among these processes evaluated, chemical treatment (using zinc sulfate and/or aldehyde) provides deodorizing and disinfection only. The others, provide treatment including removal of chemicals, suspended solids, and disinfection or sterilization.

Experimental results indicated carbon adsorption, and electrolysis could produce effluent meeting flushing water quality criteria in cost-effective manner. Health hazard, users acceptability, operation reliability, maintainability, safety, power requirement, space requirement, weight, shelf life and cost were used for effectiveness measurement criteria in the cost-effectiveness analysis.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Reuse of Municipal Wastewater by Volunteer Fresh-Water Wetlands

AUTHORS: Jeffrey C. Sutherland and Frederick R. Bevis

AFFILIATION: Williams & Works Engineers, Grand Valley State College

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

The municipal wastewater treatment system at Vermontville, Michigan (population 900) consists of two facultative stabilization ponds (4.4 ha = 10.9 ac), followed by four diked surface (flood) irrigation fields (5.3 ha = 13.1 ac) constructed on clayey soils. The system is located on a hill with the ponds uppermost and the fields at descending elevations. Now in the eighth year of operation, the fields are nearly overgrown with volunteer emergent aquatic vegetation, mainly cattail (Typha spp.). The fields are equipped to drain by gravity overflow, one into the next. In spite of slow internal drainage, seepage rates are high enough that overflow occurs only with rainfall.

The Vermontville system is being studied (NSF, ENV77-20273, May, 1978 - June, 1980) from the points of view of sanitary wastewater treatment and wetland quality. Some questions which need to be answered in searching for economical wastewater treatment schemes involving volunteer wetlands are:

1. What combination of circumstances would make such systems an effective alternative to conventional sanitary wastewater treatment for small communities?

2. How should the concept of protective management be applied to new wetland environments which exist solely because of the beneficial wastewater?

The following studies directed to those questions will be largely accomplished in 1978, and are the subject of this paper.

1. Estimates of vegetation biomass, productivity, and phosphorus and nitrogen in the annual crop.

2. Estimates of the nutrient amounts potentially removable through harvesting of the standing crop.

3. Wildlife values associated with the wetlands, compared with nearby freshwater wetlands.

4. Documentation of environmental water quality conditions including factors related to nutrient feedback by vegetation in the absence of harvesting.

5. Energy and overall O & M costs for Vermontville-type systems vis-a'-vis mechanical-chemical and upland irrigation tertiary treatment systems serving small communities.

ABSTRACT

WATER REUSE SYMPOSIUM
MARCH 25--30, 1979
WASHINGTON, D. C.

TITLE OF PAPER: Development of an Environmental Service Module

AUTHORS: 1) Duncan K. Smith, 2) A. P. Cadotte, and 3) D. R. Day

AFFILIATION: 1&2) Ontario Research Foundation, 3) Defense and Civil Institute of Environmental Medicine

DATE OF SESSION: Thursday, March 29 *SESSION NO:* Poster

The design of an air-transportable Environmental Service Module, an integrated water purification, solid waste disposal and sewage treatment system for 100 - 200 man groups in the North, is displayed. The treatment processes with provision for recycling up to eighty percent of the water used in the facility are presented.